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# BOTANICAL GAZETTE

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## A FOSSIL SEQUOIA FROM THE SIERRA NEVADA.[1]

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(WITH PLATES XVIII AND XIX)

AMONG the material of fossil woods stored in the basement of the Botanical Museum of Harvard University is a large piece from the line of the Central Pacific Railway. It is catalogued as no. 7354 and is described on the label as "From tunnel no. 1, Central Pacific R. R., Blue Gap, Sierra Nevada Mountains. Elevation above the sea 4520 ft. Found under 60 ft of conglomerate." There is no further information as to the time of its collection or the formation from which it was derived. As the piece of wood in question had the color and general texture of a Sequoia, I was led to investigate its microscopic structure, with the result that it turned out to be a new species of the genus, presenting a number of interesting and novel features.

Dr. F. H. KNOWLTON, of the United States Geological Survey, has expressed the opinion that the wood which forms the subject of the present article is of the age of the auriferous gravels, *i. e.*, Miocene; but is unable to state positively that this is the case, on account of the absence of definite evidence. As the location of the specimen is clearly indicated, it will probably be an easy matter to determine subsequently its exact geological horizon. In any case the morphological features which it presents are of sufficient interest to justify a description at the present time.

The fragment of wood in its original condition as taken from the collection was about 1.5 m long. One end was much frayed and

[1] *Contributions from the Phanerogamic Laboratories of Harvard University.* No. 1.

water-worn; the other showed a fractured surface as if it had been broken away from a longer piece. This supposition is strengthened by the fact that there are a few ax marks on the broken end of the specimen. The piece measured about $15^{cm}$ in the radial direction and about $18^{cm}$ tangentially, and is rounded in these directions apparently by water carriage. There are about three hundred rings of growth, and perpendiculars drawn from these show that the original trunk of which the specimen under discussion is a fragment must have been at least six feet in diameter. It was possibly much larger, since in all probability a good deal of ligneous tissue has disappeared from the outer surface of the specimen. The wood had undergone comparatively little alteration from decay, and the fact that it is only very slightly impregnated with silica, easily removed with hydrofluoric acid, makes it very favorable for investigation. The preservation even of minute details of structure is far beyond that of any other fossil Sequoia with which I am familiar.

*Fig. 1* shows some of the characteristic features of a transverse section of the fossil wood under discussion. The annual rings are well marked and very regular even in sections of greater area than that shown in the figure. Two peculiarities stand out above all others in *fig. 1*, viz., the apparent absence of resin cells, such as ordinarily occur in cupressineous woods, and the presence of resin canals in both horizontal and vertical planes, a feature characteristic of the Abietineae and hitherto unknown in the cupressineous series. The rings of growth are mostly composed of thin-walled tracheids, but suddenly toward the outer border of the annual zone appear a few thick-walled tangentially flattened elements. In one of the annual rings may be seen a number of open spaces rounded in outline. These are vertical resin canals in transverse section, and are confined to the spring wood. A very broad horizontal duct originates outwardly from the vertical series of resin canals just described and passes beyond the boundary of the figure. *Fig. 2* shows some thin annual rings highly magnified. The tracheids are more often square than pentagonal or hexagonal in outline. The pits are confined to their radial walls, except in the case of the thick-walled autumnal tracheids, and are obviously in two rows as seen in transverse section. The tangential pits which are sometimes found in the spring wood of the

living Sequoias are not found in the present species.[2] On the left of the figure may be seen a medullary ray. The cells are obviously very long, and in the present instance extend across a complete annual ring. The elements still retain their dark granular contents, the so-called resin globules. In the present species of Sequoia the resinous material is mainly found in the medullary rays and scarcely at all in the wood, in this respect presenting a marked resemblance to Tsuga and Abies among the Abietineae. There is, however, a certain number of resin cells on the outer face of the summer wood. One of these elements is shown in the second annual ring and on the right of the figure. This feature, too, finds a parallel in Tsuga among the Abietineae.

*Fig. 3* shows part of a tangential section of the wood of our species, under low magnification. The irregular dark striping of the center of the figure represents the summer wood, while the light-colored lateral portions correspond to the spring wood. Most of the medullary rays appearing in the figure are so small as to be scarcely discernible, but some of them are enormously enlarged to constitute fusiform rays, which contain horizontal resin canals. Most of these canals appear to be empty, but some are obviously filled with coarsely granular contents. The appearance presented in the section shown in our *fig. 3* is somewhat exceptional for the species under discussion. In most cases a tangential section of the wood reveals no fusiform rays and no horizontal resin canals.

*Fig. 4* appears to afford an explanation of the peculiarities seen in *fig. 3*. The magnification in this instance is not great, and as a consequence a large number of annual rings are present. These become arched and suffer interruption toward the lower part of the figure. In this case we have obviously to do with a healing wound. The interruption in the continuity of the annual rings indicates the time at which the injury took place, and outside this gap the rings of growth are unusually thick, as is ordinarily the case in traumatic wood. There is a reaction farther out and the rings become much thinner, again to increase their thickness once more still farther out. From the right border of the wound a horizontal

[2] PENHALLOW, D. P., Generic characters of North American Taxaceae and Coniferae. Trans. Roy. Soc. Canada **2**: 1896.

resin canal can be seen making its way outward through all the annual rings seen in the plane of the figure. By careful inspection it is also possible to make out that there are vertical canals in series in the spring wood of the first ring of ligneous growth subsequent to injury. *Fig. 5* shows part of another section through the same wound more highly magnified. The tangential series of resin canals in the spring growth of the first traumatic ring can now be clearly seen. Passing off from these can be made out three horizontal ducts, the most median of which does not actually communicate with the vertical canals in the plane of the present section. To the right of the figure a short tangential series of ducts can be seen in the second ring of growth formed after the wound. No horizontal canals originate from this weaker series of vertical canals. *Fig. 6* is taken from the center of the wounded region, and the annual rings immediately abutting on the wound are the second and third formed subsequent to the injury. Each of them contains a weak series of vertical canals in the vernal wood, but these do not give rise to any horizontal ducts. *Fig. 7* shows a part of another section through the same wound, somewhat more highly magnified. The vertical canals of the spring wood are now clearly discernible, and from these are passing off in the horizontal direction three huge resin canals. Two of these are more or less completely filled by parenchymatous tyloses.

We are now in the position to discuss the resin canals vertical and horizontal appearing in *figs. 1* and *3*. It is a well-known fact that in the Abietineae the formation of resin canals may be brought about as the result of wounds. The present writer has shown that the same feature is found in the living species of Sequoia.[3] In the existing species of Sequoia the formation of traumatic resin canals is entirely confined to the vertical plane, so far as our present knowledge goes. In those Abietineae which give rise to ligneous resin canals only as a result of injury they are also confined to the vertical plane, except in the genus Cedrus, where, as the present author shows in an article about to be published, they are formed horizontally as well. Three cases of injury have been found in the fossil Sequoia at present under consideration, and in each of the three cases the injuries led to the

[3] JEFFREY, E. C., Memoirs of the Boston Society of Natural History **5**: no. 10.

formation of traumatic resin canals. Where the irritation is most severe, *i. e.*, in the first annual ring formed after injury, there are apt to be both horizontal and vertical canals; while in the later formed rings the impulse gradually dies out and only vertical canals originate. The horizontal canals run in considerable numbers from the margins of healing wounds. *Fig. 3* represents a section through such a patch of traumatic horizontal canals. *Fig. 8* shows the appearance of the large horizontal canal to be seen on the left of *fig. 3* when somewhat more highly magnified. The enormously enlarged medullary ray is almost entirely taken up by the huge resin canal, which in turn is occluded by a mass of cells constituting a tylosis. *Fig. 9* shows a smaller duct from the right of *fig. 3* somewhat more highly magnified than the foregoing. The continuity between the tylosis and the wall of the duct can clearly be made out in this figure. The cells constituting the walls of the traumatic resin canals in the Sequoias are thick-walled and much pitted, and generally contain in greater or less abundance the dark brown masses which occur in the resin cells of the wood of the Cupressineae in the larger sense. Not all of the canals contain tyloses in the fossilized material, but it is probable that they were universally present in the living tree.

*Fig. 10* shows the transition from a vertical to a horizontal duct as seen in vertical radial section. The great difference in size which ordinarily obtains between the two sorts of ducts is very apparent. The abundant tyloses are also a feature of the horizontal ducts, although this phenomenon is also occasionally found in the vertical resin canals.

Vertical traumatic resin canals may extend very far above and below the wound, so that in small isolated pieces of wood their relation to injury is not obvious. From a wide knowledge of living forms of conifers in relation to injury, I am in the position to state inductively that rows of vertical ducts occurring vertically and tangentially in coniferous woods are always due to injury. It has been possible to show that this is the case wherever the material was abundant enough to warrant a definite conclusion.

Horizontal traumatic canals may pass outward from a healed wound through many annual rings. In one instance horizontal canals extended through thirty-eight rings of growth, ending in another

vertical series of ducts, and from this vertical series again other horizontal ducts passed outward beyond the limits of the piece of wood at my disposal. In another case I was able to follow the course of a horizontal duct through over seventy annual rings before it finally tapered off and ended blindly. Although the horizontal canals always start from a vertical series, they by no means always end in the next outward vertical series, even when one is present. More frequently they end blindly, as in the one last described above. The formation of new series of vertical canals may recur in remote rings of growth, and these are nearly always united by horizontal canals.

It will be convenient at this stage to consider more particularly the structure of the wood parenchyma, since it is of considerable diagnostic importance. Our *fig. 2* shows the scantiness of the parenchyma as seen in transverse section through the wood, and also that it occurs on the face of the summer wood. Both these features are unusual, for in the living Sequoias the resiniferous parenchyma is particularly abundant and is found throughout the annual ring. Our fossil also presents a contrast in this respect to the woods of other extinct Sequoias. PENHALLOW[4] describes his *S. Langsdorfii* as having abundant resin cells throughout the annual ring and appearing also in a rudimentary form on the face of the summer wood. In another species, *S. Burgessii*, according to this author,[5] resin cells abundant throughout the ring are most numerous on the face of the summer wood. In the *S. magnifica* of KNOWLTON[6] the distribution of resin cells throughout the annual growth seems to be somewhat uniform. Longitudinal sections of the wood of the species under discussion, taken in numbers both in the tangential and radial planes, show clearly that the absence of resin cells from all locations except the face of the summer wood is not due to disappearance through decay, for there is no evidence of the existence of parenchymatous elements elsewhere than on the face of the summer wood. *Fig. 11* shows the appearance of the resin cells of our species in longitudinal section. They are long narrow elements comparable among living species to those of *S. gigantea*

[4] PENHALLOW, D. P., Notes on Tertiary plants. Trans. Roy. Soc. Canada **9**.

[5] *Op. cit.*

[6] KNOWLTON, F. H., Geology of the Yellowstone Park. Monographs of U. S. Geological Survey **32**: pt. 2.

rather than to the stouter, shorter similar elements of *S. sempervirens*. They may be seen on the outside of the summer wood in two contiguous annual rings. They contain a very small number of resinous globules. On the left of the figure is a longitudinal section of a vertical resin canal.

In *fig. 12* is seen a longitudinal section of a medullary ray of the species under consideration. The lateral walls of the ray which are in contact with the tracheids are characterized by so-called bordered pits, which owe their double contour to the fact that the outline of the pit on the side of the tracheid is different from that on the side of the medullary ray cell. The medullary ray of the present species of Sequoia is strikingly different from that of the two living species in features other than the crucial one of the lateral bordered pits. There are distinctly differentiated marginal cells, broader than the central cells and having two to three radial rows of pits instead of the single row found in the central cells. The marginal cells are further particularized by their undulating borders, the tops of the undulations corresponding to the walls of the tracheids. They present an additional contrast to the central cells in the fact that they are generally without tanniniferous contents and often contain very large clinorhombic crystals, lodged in cysts derived from the cell wall. The presence of crystals finds a parallel in the genus Abies among the Abietineae. STRASBURGER has noticed their occasional presence in *Abies pectinata*. I have found them to be very numerous in *A. concolor* and fewer in *A. grandis*, *A. bracteata*, *A. nobilis*, and *A. magnifica*. In Abies the crystals may or may not be associated with a dark brown matrix similar to that found in the resin cells of cupressineous woods and in the so-called crystallogenous cells which occur in the phloem of many of the Coniferales; but I have not found them inclosed in cysts derived from the cell wall as they are in the fossil species of Sequoia here described. Where the medullary rays are very deep the specialized marginal cells, instead of constituting a single row on the upper and lower borders of the ray, as is shown in our *fig. 12*, may be present to the number of three or four rows. In deep rays specialized cells may also occur in the middle of the ray, just as is occasionally the case with the tracheidal cells in the rays of certain Abietineae. Another feature which differentiates our species

from the living species of Sequoia is the very abundant pitting of the tangential walls of the medullary ray cells. This is an additional point of resemblance to the Abietineae. Through the kindness of Professor PENHALLOW I have had the opportunity of examining the type specimens of his *Sequoia Langsdorfii* and *Sequoia Burgessii*. The state of preservation of the medullary rays is very indifferent in these species; but so far as could be made out they do not possess the peculiar marginal cells and the strong pitting of the terminal (tangential) walls which are characteristic of our species. The *Sequoia magnifica* of KNOWLTON has badly preserved medullary rays, according to the author's description.[7] Professor PENHALLOW has seen sections of our species and agrees that it is new and unlike any which have been described. The name *Sequoia Penhallowii* is proposed for it in recognition of Professor PENHALLOW'S great services to the paleobotany of the Coniferales. The following is the diagnosis:

**Sequoia Penhallowii, n. sp.**

*Transverse.*—Rings of growth rather narrow, with sharply marked but thin summer wood. Rings regular, or if varying in thickness varying uniformly and without violent transitions except as the result of injury. Resin canals present in both the vertical and horizontal planes apparently only as the result of injury. The resin canals when present surrounded by resin cells, containing dark brown resin. Resin cells inconspicuous and confined to the face of the summer wood, except in the case of injury, where they may be present throughout the zone of annual growth. Tracheids of the spring wood very large and with pits on the radial walls only. Tracheids of the summer wood with tangential pits.

*Radial.*—Rays without tracheidal cells, but with distinctly differentiated marginal cells. Lateral pits of ray cells elliptical and bordered, larger in marginal cells. Rows of pits single in the central cells of the ray and two to three seriate in the marginal cells. Medullary ray cells covering one to four tracheids, the central ones resiniferous, the marginal generally empty, sometimes containing large clinorhombic crystals inclosed in cysts derived from the cell walls. Marginal cells with undulating free border, deeper than central cells. End walls of the cells of the medullary rays very strongly pitted. Longitudinal walls of ray cells also pitted and rather thick. Rays contain resin canals in the case of injury, which take their origin from similar vertical canals running in the wood. Resin canals of the rays sometimes ending blindly and sometimes in a more external series of vertical canals, often extending through many annual rings, varying greatly in size and frequently occluded by tyloses. Spring tracheids generally with two rows of opposite pits, which often alternate in the ends.

[7] *Op. cit.*

*Tangential.*—Rays of one kind only in uninjured parts of the wood. Fusiform rays present with linear rays in the case of injury and varying greatly in size. Fusiform rays when present generally with central resin canal, which is often occluded by tyloses. Linear rays varying greatly in depth. No pits on the tangential walls of the spring tracheids. Pits on the tangential walls of the summer tracheids numerous, generally not in rows.

## CONCLUSIONS.

The greatest interest connected with the study of any extinct species is the light it throws on the structure and relationships of living forms. In the case of *Sequoia Penhallowii* the first point in this connection is its affinity with the living species of the genus. The very regular rings of growth and the very thin summer wood find their nearest parallel in *S. gigantea.* It is possible, however, that this similarity in structure of the wood may be due only to a similar mountainous habitat, since such surroundings tend, as is well known, to produce regular growth rings in living trees. For example, wood of spruce grown at high altitudes is particularly fitted for turning and the manufacture of fiddles on account of the regularity of the annual rings. The narrowness of the zone of summer wood, however, cannot be explained in this fashion. The long narrow resin cells of the wood in our species also most nearly resemble those of *S. gigantea.* The wide spring tracheids with their double rows of radial pits present a feature of resemblance to *S. sempervirens* rather than to *S. gigantea;* but this feature cannot be regarded as conclusive, since in some of the fossil Sequoias known only by impressions the larger free leaves of the *S. sempervirens* type were correlated with cones likes those of *S. gigantea.* The greater transpiration thus indicated may well have been provided for by broader and more numerously pitted tracheids. A very strong argument for the association of our species with *S. gigantea* is the fact of their similarity of geographical distribution, for the fossil under discussion came from a cañon of the Sierra Nevada Mountains, which are the home of the living *S. gigantea.* The weight of evidence seems to point to *Sequoia Penhallowii* being somewhat more closely allied to *S. gigantea* than to *S. sempervirens.*

We may now turn to the question of the light which the study of the present species throws on the general problem of the phylogeny

of the Coniferales. Attention has been called in the descriptive part of this article to the striking points of structural resemblance presented by *S. Penhallowii* to certain abietineous species. The medullary rays, for example, although they lack the marginal tracheidal cells characteristic of the typical Abietineae, have distinctly differentiated marginal cells which find a close parallel in the medullary rays of the genus Abies. Further, the marginal cells of the medullary rays of our species are crystallogenous, as are those of Abies. Another feature of strong resemblance to the Abies and the Abietineae is the marked pitting of the terminal walls of the medullary ray cells. This character is absent or poorly marked in the cupressineous series. Equally strong indications of abietineous affinities are to be found in the structure of the wood. The resin cells, which are such a marked feature of cupressineous woods, are almost absent in our species. The few which are present are confined to the outer surface of the summer wood, as in the abietineous genera Tsuga and Abies. The strongest argument, however, for the transitional nature of our fossil is that presented by the ligneous resin ducts. As has been pointed out in the foregoing paragraphs, resin canals occur in both the horizontal and vertical planes in the wood of *S. Penhallowii* as the result of injury. In this feature it presents a striking resemblance to the normal state of affairs in the abietineous genera Pinus, Picea, Pseudotsuga, and Larix. In another place[8] I have pointed out that the normal occurrence of vertical resin canals in the wood of the cone, cone scales, peduncle, and *first* year's growth of strong branches of sexually mature trees of *S. gigantea* is good evidence that this species had come from ancestry characterized by the presence of ligneous resin canals. In both *S. gigantea* and *S. sempervirens* resin canals of the vertical type only occur in the secondary wood as the result of injury. In view of the conditions found normally in *S. gigantea* in the matter of the occurrence of resin canals, I have argued that traumatic resin canals are a case of reversion in the injured wood of *S. gigantea* and *S. sempervirens*. Here we have an example of the value of experimental morphological evidence when confirmed by that of comparative anatomy. Further it may be pointed out that

[8] JEFFREY, E. C., The genus Sequoia. Memoirs of the Boston Society of Natural History **5**: no. 10.

if it is possible to recall experimentally morphological characters, which have entirely disappeared (as in the case of the ligneous resin ducts of *S. sempervirens*), the range of possibility in tracing phylogenetic relationships will be greatly extended. In our fossil the traumatic resin ducts occur in both the horizontal and the vertical planes, and thus present a very close approximation to the condition occurring normally in Pinus. There is, however, a difference in the arrangement of the canals, for in Pinus they are distributed regularly throughout the wood and form an anastomosing system, while in *S. Penhallowii* the vertical canals are confined to remote annual rings and the horizontal canals form a very incomplete system of connecting commissures. It is interesting to note that *S. Langsdorfii* as described by PENHALLOW has only vertical canals, while *S. Burgessii* described by the same author has only radial ones. Had the material of the latter species been as abundant and as easily manipulated as in the case of our fossil, I am disposed to think that vertical canals would have been found as well. It is a noteworthy fact that in three out of the four woods of fossil Sequoias which have been recently described, resin canals similar to those of the Abietineae have been found; or, to state it in another way, the oldest woods of Sequoia of which we have any reasonably complete knowledge more nearly approximate in structure the wood of the Abietineae than do those of their living descendants. This fact, taken in connection with the great geological age of the Abietineae, makes it very probable that the Sequoias, and as a consequence the Cupressineae in a broader sense, have come from an abietineous ancestry. This conclusion is quite in harmony with evidence derived from the study of the female cone, and other important data, as I have pointed out at length in a forthcoming memoir on the Abietineae.

## SUMMARY.

A fossil Sequoia from the Auriferous Gravels (Miocene) of the Sierra Nevada Mountains, although presenting features of wood structure which unite it with the living Sequoias, possesses other features which strongly suggest the Abietineae. The paucity of resin cells present only on the outer face of the summer wood, the highly developed medullary rays, and the traumatic resin canals

running both in the horizontal and vertical planes point strongly toward the Abietineae. The species is new and has been named *Sequoia Penhallowii*. It appears to be more closely allied to the living *S. gigantea*, and has, moreover, the same geographical occurrence. A formal diagnosis is given in the body of the article.

In conclusion I wish to express my obligations to Professor R. T. JACKSON for permission to investigate the material described in this article, and to Professor D. P. PENHALLOW for the opportunity of examining his type slides of fossil Sequoias.

HARVARD UNIVERSITY.

## EXPLANATION OF PLATES XVIII AND XIX.

*PLATE XVIII.*

FIG. 1. Transverse section, including several annual rings and showing both horizontal and vertical resin canals in *Sequoia Penhallowii*. × 30.

FIG. 2. Transverse section of thin growth rings of same species. × 180.

FIG. 3. Tangential section of the same showing horizontal resin ducts. × 8.

FIG. 4. Transverse section through a healed wound in the wood of the same species; on the right is a horizontal traumatic resin duct; smaller traumatic ducts can be seen in the spring wood of the three annual rings abutting on the wound. × 4.

FIG. 5. Part of another section through the same wound, showing three horizontal ducts on the left; the smaller vertical ducts of the spring wood can be more clearly seen on account of the greater magnification. × 8.

FIG. 6. The central region of still another section through the same wound showing small vertical ducts in the spring wood. × 8.

*PLATE XIX.*

FIG. 7. Another of the same more highly magnified from the margin of the wound. × 16.

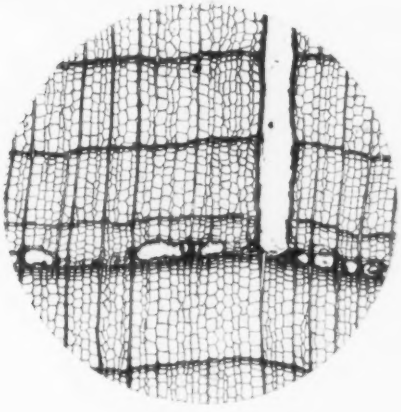
FIG. 8. Transverse section through one of the large horizontal ducts seen in *fig. 3*. × 40.

FIG. 9. Section through a smaller duct from the same preparation as that illustrated in the last figure. × 60.

FIG. 10. Section showing the relation between a horizontal and a vertical duct; the former is blocked by a tylosis. × 50.

FIG. 11. Longitudinal section, showing the scanty resiniferous parenchyma on the face of the summer wood in two annual rings; a vertical resin canal is also shown. × 60.

FIG. 12. Radial section to show the topography of a medullary ray of medium size: on the borders of the ray can be seen the empty crystallogenous cells. × 60.



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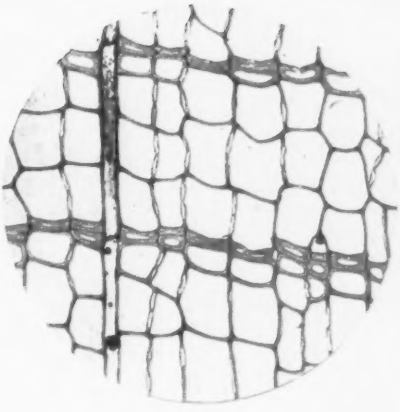

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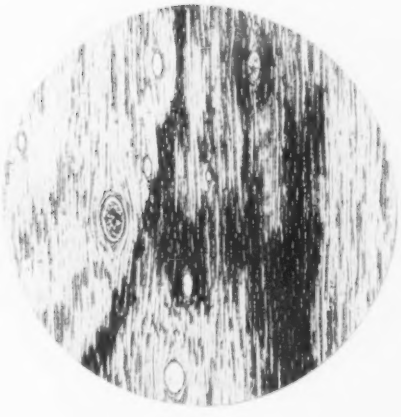

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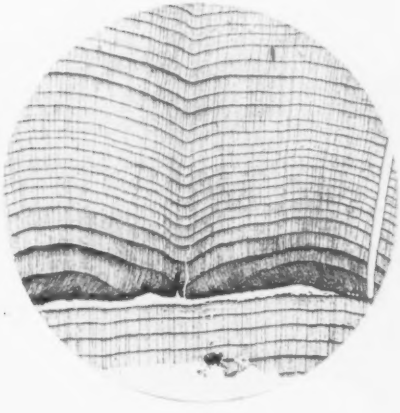

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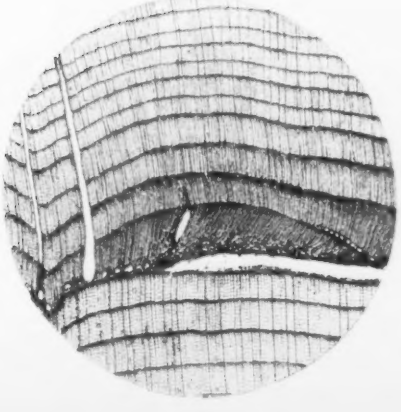

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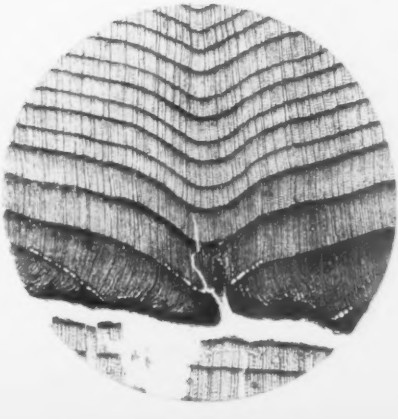

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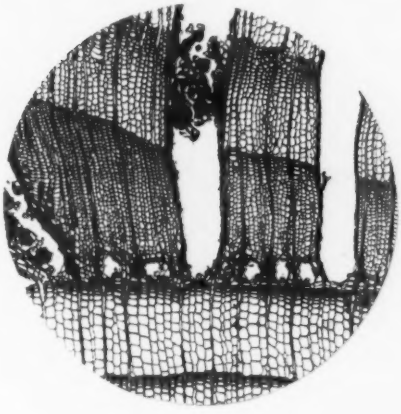

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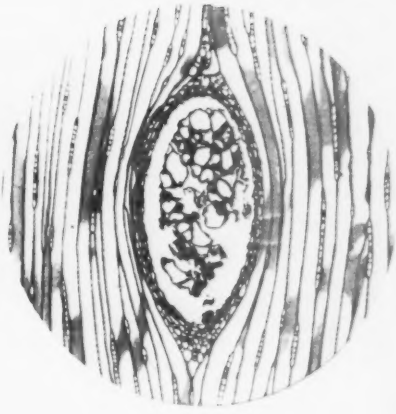

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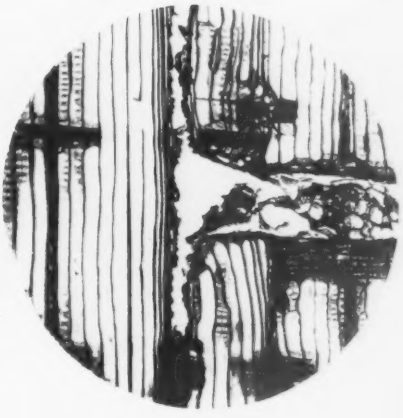

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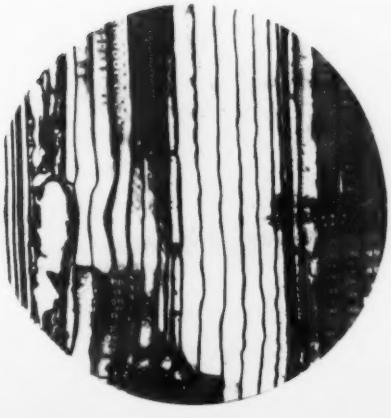

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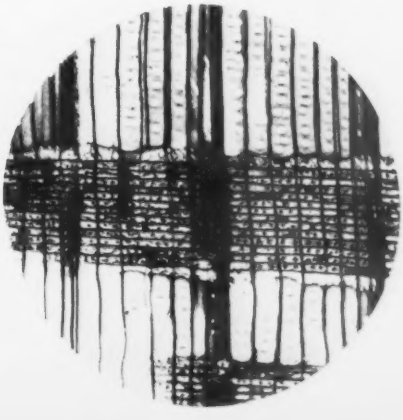


12

HELIOTYPE CO., BOSTON

# PLACE-CONSTANTS FOR ASTER PRENANTHOIDES.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LXIV.

GEORGE HARRISON SHULL.

(WITH EIGHTEEN FIGURES)

## I. INTRODUCTION.

GEOGRAPHIC isolation has long been accredited as an important factor in the process of evolution, but with the introduction of methods calculated to demonstrate the evolutionary processes an altogether new conception has been gained regarding the importance of locality as a modifying factor. Statistical methods have shown that the organisms of any species from different stations, often quite near each other, are not to be considered homogeneous, and that in order to establish a proper basis for comparison investigations must deal with definite areas. The modal condition of any species prevailing on such a limited area is known as a "place-mode" for that species at that place.

The importance of determining and recording place-modes for various species was first emphasized by DAVENPORT (1899*a*), and in response to his appeal a considerable number of local statistical studies have been made. Some of these studies have shown that the determination of place-constants is not so simple a problem as was at first supposed. As a result of my earlier studies on Aster (SHULL 1902) it was shown that the establishment of place-constants for a species of Aster would involve the collection of all the heads produced during the season, since there is a continuous and more or less regular change in the variable characters from day to day throughout the season. It was suggested there that considerable differences might also be presented by the same population from season to season. The results of a number of studies on various species by other investigators, both before and since my study of Aster, either lead to the same conclusion or admit of the same explanation (BURKILL 1895, MACLEOD 1899, LUDWIG 1901, TOWER 1902, YULE 1902, PEARSON 1903, REINÖHL 1903, etc.).

TOWER (1902) discusses the bearing of these results upon the establishment of place-constants, and concludes "that the 'place-mode' for a species or for a character of a species should represent the average prevailing condition at a given place during a period of observation continued through years or long enough to eliminate the effect of secular fluctuations."[1]

It has been proved conclusively that conditions of variability which are a function of place are masked by others associated with time, and before we can satisfactorily arrive at the one the other must be eliminated. In the efforts which have thus far been made to establish place-constants this fact has not been taken into account. Indeed, we do not yet know how to take it into account, since no adequate investigation has been made of changes in variability which take place during the season and from season to season. It was to add to our knowledge of such secular variation and to contribute by its elimination to the establishment of true place-constants that the present study was undertaken.

[1] In his summary TOWER gives the following definition: "A 'place-mode' is the average prevailing state of a homogeneous lot of individuals [*i. e.*, of the same pleomorphic condition and stage of development] characteristic of a particular place and season, as determined by observations carried on long enough to eliminate the effects of secular climatic fluctuations." The limitation of a place-mode to a *particular season* was plainly unintentional, as it is inconsistent with the requirement that the observations be carried on long enough to eliminate the effects of secular climatic fluctuations.

PEARSON (1902) objects to this definition as not being biometric. He says: "It might refer to any constant whatever of the frequency—to the mean, the mode, the variability, or indeed to the whole frequency distribution itself." TOWER'S application of the term place-*mode* to the *average prevailing condition* of a homogeneous population is in harmony with a well-known philological principle which has wrested very many words from their original signification to meanings of greater or less inclusiveness, because the original concept as limited by the literal meaning of the symbol used proved to be of comparatively little importance. In very many instances the *mode* is the least important constant involved, and in others—particularly in the variation of plants—the theoretical mode is at present indeterminable. As no one thought, in studying place-modes, of limiting his studies to the theoretical *mode*, it was not unnatural so to extend the meaning of place-mode as to involve all the quantitative relations of a population.

While it was evidently DAVENPORT'S intention in proposing the word "place-mode" to use it in its strict mathematical sense, a reference to his definition will show how easy it was to make it include the entire condition of the population. He says (1899*a*): "I use the word 'place-mode' to embody a well-known idea, namely that a

## II. MATERIAL AND METHODS.

This study is based upon the flowering heads of *Aster prenanthoides* Muhl. collected thrice a week from the same area which furnished the serial collections for my earlier studies (SHULL 1902). This species is in some ways an ideal subject for studies of this kind. The heads are beautifully regular, as may be seen in *fig. 1*. They are little subject to injuries, and almost the only heads which must be thrown away are those in which insect larvae have hatched and subsisted upon the developing flowers. Such cases are not numerous, amounting to less than 2 per cent. of the heads collected this year.

FIG. 1.—*Aster prenanthoides* at Clifton, Ohio.

The personal equation was eliminated in the same manner as in my former work, *i. e.*, by the collection of every head that bloomed on a naturally circumscribed area. The method used in making the counts was also the same, the heads being completely dissected. This method prevents the errors which will frequently occur in the counting of rays without complete dissection — errors

species has a different *mode* (*i. e.*, a different *prevailing* condition of size, color, etc.) in different localities. The person who seeks to determine a place-mode determines the prevailing dimension of the principal measurable qualities (and practically all qualities of organisms are measurable) of a species as it occurs in the locality in question."

It seems desirable in applying the exact methods of the mathematician to biology to retain the exact mathematical significance of the word "place-mode," though the term then becomes of comparatively little usefulness. As a more inclusive term, involving the characteristics of any or all the measurable qualities of a species as represented by a lot of individuals occurring at any place in question, let us adopt the word *place-condition* or *place-habit*. We may then say that we investigate the place-habit or place-condition of a species at a particular place in order to determine or establish the place-constants, among these being the place-mode.

resulting from the loss of rays due to age or other causes—and it saves the necessity of discarding any material on this ground, since the remains of the ray-flowers are always distinguishable from the disk-flowers when they are separated.

It ought not to be necessary in work of this kind to give assurance that no material has been arbitrarily discarded, either in collection or in seriation, but the importance of this matter seems to be too little appreciated. If one student arbitrarily discards material, who else in working over the same material will arbitrarily discard on the same basis? And if an investigation cannot be repeated by another investigator with at least approximately identical results, of what value is it? TOWER (1902) assumed that his failure to get a mode at 34 in *Chrysanthemum Leucanthemum* might be due to the fact that he discarded a number of heads on account of age. He states that counts of some of this rejected material showed that all of the heads had a large number of rays. What would have been the result had he counted all the heads he rejected? Miss SMALLWOOD (1903) "arbitrarily threw out the small" specimens of beach-flea and then presented statistics as to the size and variability of the remainder, as if these data could have either interest or scientific value.[2] If anomalies appear when all the data are seriated, they should be explained if possible, but explained or unexplained the data should be given, because these have value whether the explanation has or not.

In calculating the various constants I have again used the formulae tabulated in DAVENPORT'S (1899*b*) *Statistical methods*, except that instead of DUNCKER'S method of calculating the coefficient of correlation I have used the neat method adopted by YULE (1897), which may be expressed by the formula

$$\rho = \left( \frac{\Sigma f x' x''}{n} - \nu_1' \, \nu_1'' \right) \frac{1}{\sigma' \, \sigma''},$$

in which $x'$ and $x''$ are the deviations from an integral assumed mean of subject and relative classes respectively, $f$ is the frequency of occurrence of each combination of subject and relative deviations,

[2] In justice to Miss SMALLWOOD it should be said that her paper deals chiefly with the ethological relations of the beach-flea, and that she seems to have appreciated the unsatisfactory character of her quantitative results.

$n$ is the whole number of variates, $v_1'$ and $v_1''$ are the deviations of the assumed means from the true means, and $\sigma'$ and $\sigma''$ the errors of mean square or "standard deviations" respectively of the subject and relative categories.[3]

### III. LOCALITY AND HABITAT.

Flowers collected from the hillsides differ in a marked way from those of the same species collected in the lowlands of the same locality, as has been shown in many instances by DE VRIES, LUDWIG, REINÖHL, and others. This is a question of habitat. It remains an unsolved problem whether plants are not so sensitive to edaphic and local climatic conditions as to make impossible the derivation by statistical methods of anything more fundamental than the fact and the degree of this extreme sensitiveness. This problem can be solved only by long and carefully conducted investigations. In order that we may discriminate between the influences of habitat and locality in making studies in variation, it becomes necessary to record as carefully as possible the habitat in which the material has been collected, and so to indicate the locality that future investigators may visit the identical area studied.

The definite character both of habitat and of locality has strongly commended the choice of this particular area of *Aster prenanthoides* for such thorough investigation as is needed to elucidate the complex problems involved in work of this kind.

Clifton is a small village on the boundary between Clark and Greene counties, Ohio, in lat. 39° 48′ 43″ north and long. 83° 48′ 41″ west. The Little Miami River, on whose northern bank the village lies, occupies a post-glacial channel in massive gray Niagara limestone, forming a deep and narrow gorge widely known for the beauty of its scenery. About one kilometer west of the village two small streams enter the river from the north. Both of these tributary streams have cut gorges in the limestone, but, being unable to corrade their beds so rapidly as does the river, they have been left high above the level of the river in hanging valleys. At about 10–20 m from the river the Yellow Springs turnpike crosses these streams by two stone arches. The area chosen as the source of material for this study is

[3] This method displaces DUNCKER'S method in the second edition of DAVENPORT'S *Statistical methods* which has just appeared.

that portion of the more westerly tributary ravine lying between the road and the precipice over which the stream falls into the river. The locality is indicated by a star on the map (*fig. 2*).

An important theoretical consideration is the relation of the locality to the whole range of the species and to the direction of its migration.

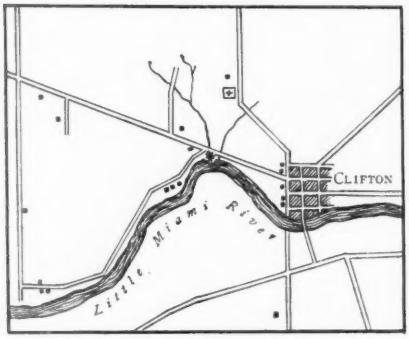



FIG. 2.—Map of Clifton and vicinity; station for *Aster prenanthoides* marked with a star.

What relation does the variability of a species near its limit of range bear to that at its center? Is there a progressive change of variable characters along the lines of migration radiating from the center of distribution of the species? ADAMS (1902) accepts such progressive change as one of his ten criteria for the determination of centers of distribution. He concludes that the southeastern United States has been the principal center of post-glacial distribution for the eastern half of North America. The determination of place-constants in various parts of the range would test the value of this criterion. It is to be hoped that investigators in other places will make studies similar to this for the purpose of throwing a more certain light on these principles.

To show the relation of Clifton, Ohio, to the total range of *Aster prenanthoides* I present in *fig. 3* a map showing the range of the species as represented at the present time by specimens in the leading American herbaria. Such a map is always to some extent a commentary on the limitations of the herbaria, and does not correctly represent the relative frequency of the species in the different parts of its range. E. S. BURGESS, the well-known specialist on the genus Aster, writes that the stations in the Berkeley Hills, Mass., and in the Catskills and Shawangunk Mountains, N. Y., are really extralimital, "the species becoming common 300 miles [480 km] westward, and reaching proper development along the southern shore of Lake Erie and thence through western Pennsylvania." The fewness of

the stations in the western half of the range is due to the general scarcity of herbarium material from this area rather than to the rarity of the species. It will be seen from this map that the Clifton station (marked with a star) is very nearly central.

FIG. 3.—The range of *Aster prenanthoides* as represented by specimens in the leading American herbaria;[4] Clifton, Ohio, marked with a star.

[4] The stations represented on the map are as follows: MASSACHUSETTS: Berkeley Hills. NEW YORK: Chenango Co., Oswego Co., Tompkins Co., Andover, Big Tree, Bridgewater, Buffalo, Elmira, Macedon, Catskill Mts., Shawangunk Mts. NEW JERSEY: Woodbury. PENNSYLVANIA: Bedford Co., Chester Co., Conewago Co., Lancaster Co., Westmoreland Co., Easton, Mercersburg, Philadelphia, Trout Run. MARYLAND: Baltimore, Emmittsburg. DISTRICT OF COLUMBIA: Washington. VIRGINIA: Big Stone Gap, Pulaski, Wytheville. WEST VIRGINIA: Aurora. KENTUCKY:

The habitat of the population in question is typical of the species, if we may judge from the statements made in the various manuals, all of which agree that the characteristic habitat is along margins of streams in shady places. This fact will make it easy to find these plants growing under essentially the same conditions in other localities, and thus facilitate the establishment of place-constants which shall be

FIG. 4.—The habitat, looking south.

properly comparable. The general character of the habitat at Clifton will be best understood by a reference to *figs. 1, 4,* and *5*. It will be at once recognized that we have here an example of temporary mesophytic climax characteristic of young ravines, the luxuriance of vegeta-

Bell Co., Carter Co., Lexington. OHIO: Franklin Co., Berea, Cleveland, Clifton, Ironton, Mansfield, Wooster. INDIANA: Hamilton Co. ILLINOIS: Canton. MICHIGAN: Allegan Co., Keweenaw Co. WISCONSIN: Eau Galle, Milwaukee, Racine, Sparta. MINNESOTA: Mazeppa. IOWA: Fayette Co., Johnson Co., Ames. KANSAS: Neosho Co.

tion being due to the moderation of extremes of temperature, light, etc., the protection from winds, and the consequent maintenance of a relatively high degree of humidity. Besides the relative constancy of atmospheric conditions, it should be noted that the stream which occupies the ravine, and along whose margin the *Aster prenanthoides* is growing, is a permanent, spring-fed stream draining so small an

FIG. 5.—The habitat, looking north.

area as to be little subject to fluctuations due to the alternations of dry and rainy periods. The map shown in *fig. 6* accurately represents the present position of the stream and the location of the areas of *Aster prenanthoides* with reference to it, thus enabling the future investigator to note any changes of area or relation which might have an influence upon the variability.

## IV. RESULTS.

The collections having been made about three times a week, regardless of the number of heads which were in bloom at any time, it does not seem desirable to present curves and correlation tables

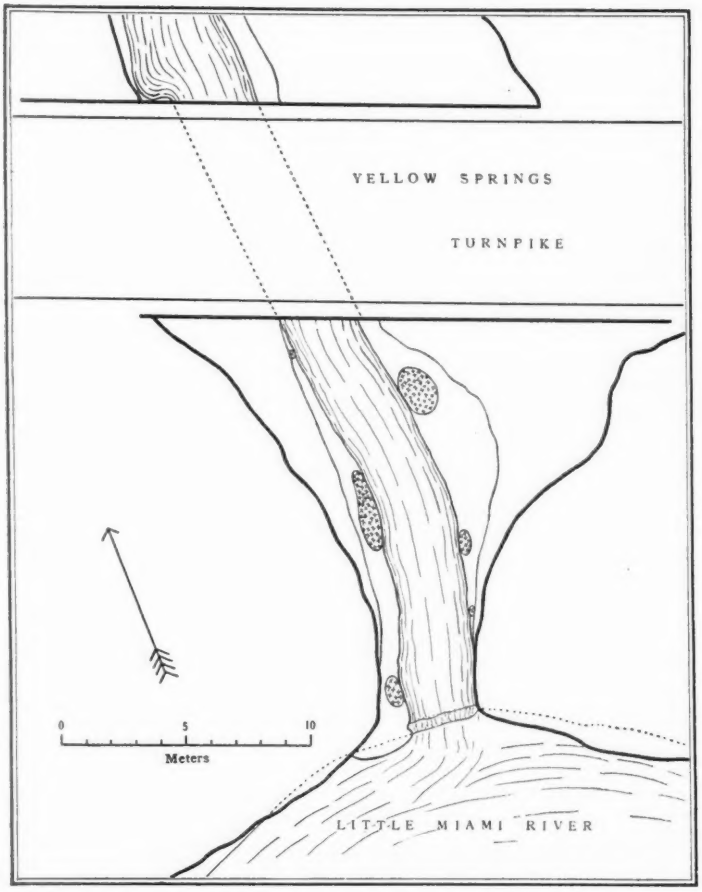



FIG. 6.—Map showing the relation of *Aster prenanthoides* to the stream at the Clifton station; heavy contours represent the upper margin of the cliffs; light contours show the limit of the flood plains; depth of ravine 5–7 m; height of hanging valley above river level 7–8 m.

of each separate collection. In order to make the original data available for any purpose to which other students may wish to turn it, I give in tabulated form the results of the several collections (Tables A, B, and C).

## TABLE A.

BRACTS.

| No. | September, 1903 | | | | | | | | | October, 1903 | | | Total 1903 | 1900 in % | 1903 in % | Sum in % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 14 | 16 | 18 | 21 | 23 | 25 | 28 | 30 | 2 | 6 | 9 | | | | |
| 18 | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 1 | .... | .13 | .07 |
| 19 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .... | .00 | .00 |
| 20 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .... | .13 | .07 |
| 21 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 1 | .... | .13 | .07 |
| 22 | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | 1 | .. | .. | 3 | .... | .40 | .21 |
| 23 | .. | .. | .. | 1 | .. | .. | 1 | 2 | .. | .. | .. | .. | 4 | .... | .53 | .28 |
| 24 | 1 | .. | .. | .. | 1 | .. | 1 | 2 | .. | .. | .. | .. | 5 | .... | .66 | .35 |
| 25 | 1 | .. | 1 | .. | 1 | 1 | .. | .. | 1 | .. | 1 | .. | 6 | .... | .79 | .42 |
| 26 | 2 | .. | .. | 1 | 1 | 1 | .. | 1 | 2 | .. | 1 | .. | 9 | .... | 1.19 | .64 |
| 27 | .. | .. | .. | .. | .. | 2 | .. | 2 | .. | 1 | 5 | .. | 10 | .... | 1.32 | .71 |
| 28 | 2 | 1 | .. | .. | 3 | 1 | .. | .. | 1 | 6 | 7 | .. | 21 | .... | 2.77 | 1.48 |
| 29 | 5 | .. | .. | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 9 | .. | 30 | .30 | 3.96 | 2.26 |
| 30 | 4 | 2 | .. | 1 | .. | .. | 2 | 6 | 4 | 5 | 6 | .. | 30 | .46 | 3.96 | 2.33 |
| 31 | 3 | 2 | .. | 1 | .. | 1 | .. | 5 | 3 | 9 | 4 | .. | 28 | .15 | 3.70 | 2.05 |
| 32 | 2 | 1 | .. | 2 | 3 | 4 | .. | 9 | 2 | 6 | 7 | .. | 36 | 1.22 | 4.75 | 3.11 |
| 33 | 1 | .. | .. | .. | .. | 3 | 2 | 10 | 4 | 5 | 10 | 2 | 37 | .76 | 4.88 | 2.97 |
| 34 | 2 | 1 | .. | 1 | 5 | 4 | 6 | 8 | 2 | 7 | 6 | .. | 42 | 2.43 | 5.54 | 4.10 |
| 35 | .. | 2 | 1 | 3 | 2 | 6 | .. | 4 | 7 | 4 | 4 | .. | 33 | .91 | 4.36 | 2.76 |
| 36 | .. | .. | .. | 5 | 2 | 5 | 3 | 6 | 6 | 5 | 1 | .. | 33 | 2.28 | 4.36 | 3.39 |
| 37 | .. | .. | 1 | 1 | 1 | 1 | 4 | 10 | 4 | 1 | 6 | .. | 29 | 3.50 | 3.83 | 3.68 |
| 38 | .. | 1 | 2 | 3 | 4 | 5 | 2 | 5 | 5 | 4 | 3 | 1 | 35 | 3.65 | 4.62 | 4.17 |
| 39 | 1 | 1 | 3 | 6 | .. | 4 | 3 | 7 | 4 | 4 | 4 | 1 | 38 | 5.62 | 5.02 | 5.30 |
| 40 | .. | .. | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 5 | 2 | .. | 22 | 5.47 | 2.90 | 4.10 |
| 41 | .. | 2 | 2 | 3 | 4 | 6 | 5 | 5 | 3 | 1 | .. | .. | 31 | 7.30 | 4.09 | 5.59 |
| 42 | 1 | 2 | 1 | 4 | 1 | 3 | 3 | 5 | 1 | 6 | 1 | .. | 28 | 5.17 | 3.70 | 4.38 |
| 43 | .. | 1 | .. | 2 | 4 | 9 | 4 | 6 | .. | 1 | .. | .. | 27 | 7.14 | 3.56 | 5.30 |
| 44 | .. | 2 | 1 | 2 | 1 | 8 | 3 | 1 | 1 | 3 | .. | .. | 22 | 6.99 | 2.90 | 4.81 |
| 45 | .. | 2 | 1 | 3 | 1 | 3 | 7 | 5 | .. | .. | 1 | .. | 23 | 6.54 | 3.04 | 4.67 |
| 46 | .. | .. | 1 | 6 | 2 | 5 | 3 | 7 | 1 | .. | 2 | .. | 27 | 5.02 | 3.56 | 4.24 |
| 47 | 1 | 3 | .. | 9 | 2 | 3 | 2 | 3 | .. | .. | 1 | .. | 24 | 5.32 | 3.17 | 4.17 |
| 48 | 2 | 2 | .. | 6 | 2 | 2 | 2 | 3 | .. | 1 | 1 | .. | 21 | 5.62 | 2.77 | 4.10 |
| 49 | 1 | 4 | 4 | 6 | 5 | 2 | 5 | .. | 1 | 2 | .. | .. | 30 | 6.99 | 3.96 | 5.37 |
| 50 | 3 | 4 | 1 | 2 | 5 | 1 | .. | .. | .. | 1 | .. | .. | 17 | 6.23 | 2.24 | 4.10 |
| 51 | .. | .. | 2 | 8 | 3 | 1 | 1 | 3 | 1 | .. | .. | .. | 19 | 3.04 | 2.51 | 2.76 |
| 52 | 2 | 1 | .. | 4 | 1 | 3 | .. | .. | 3 | .. | .. | .. | 14 | 2.74 | 1.85 | 2.26 |
| 53 | 1 | 1 | .. | 5 | 2 | 2 | .. | 2 | .. | .. | .. | .. | 13 | 1.98 | 1.72 | 1.84 |
| 54 | .. | 1 | .. | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | 3 | 1.37 | .40 | .85 |
| 55 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .30 | .00 | .14 |
| 56 | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | .15 | .26 | .21 |
| 57 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 58 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .15 | .00 | .07 |
| 59 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .46 | .00 | .21 |
| 60 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .30 | .13 | .21 |
| 61 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 62 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 63 | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | 1 | .15 | .13 | .14 |
| 64 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .15 | .... | .07 |
| | 36 | 37 | 23 | 88 | 60 | 92 | 64 | 123 | 64 | 83 | 83 | 4 | 757 | | | |

## TABLE B.

RAYS.

| No. | September, 1903 | | | | | | | | | October, 1903 | | | Total 1903 | 1900 in % | 1903 in % | Sum in % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 14 | 16 | 18 | 21 | 23 | 25 | 28 | 30 | 2 | 6 | 9 | | | | |
| 12 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | 2 | .... | .26 | .14 |
| 13 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .... | .13 | .07 |
| 14 | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | 2 | .. | 4 | .... | .53 | .28 |
| 15 | .. | .. | .. | 1 | 1 | .. | .. | .. | .. | .. | 1 | .. | 3 | .... | .40 | .21 |
| 16 | 4 | .. | 1 | 1 | .. | 2 | 3 | 2 | 1 | 1 | 1 | .. | 16 | .... | 2.11 | 1.13 |
| 17 | 2 | 1 | .. | .. | .. | .. | .. | 2 | .. | .. | 3 | .. | 8 | .15 | 1.06 | .64 |
| 18 | 5 | .. | .. | 1 | 3 | 1 | .. | 3 | 3 | 2 | 3 | .. | 21 | .00 | 2.77 | 1.48 |
| 19 | 1 | 2 | .. | .. | 4 | 3 | .. | 5 | .. | 4 | 10 | .. | 29 | .91 | 3.83 | 2.47 |
| 20 | 7 | 1 | .. | 1 | 1 | 3 | 1 | 12 | 4 | 4 | 7 | .. | 41 | .91 | 5.41 | 3.32 |
| 21 | 2 | 2 | .. | 3 | 5 | 7 | 3 | 9 | 6 | 7 | 9 | .. | 53 | 2.13 | 7.00 | 4.74 |
| 22 | 1 | 2 | 1 | 4 | 3 | 11 | 5 | 13 | 8 | 15 | 11 | .. | 74 | 5.12 | 9.77 | 7.56 |
| 23 | 1 | 1 | 5 | 5 | 3 | 8 | 5 | 12 | 6 | 7 | 6 | 2 | 61 | 5.32 | 8.05 | 6.79 |
| 24 | .. | 1 | 2 | 7 | 4 | 4 | 3 | 4 | 7 | 8 | 6 | .. | 46 | 7.30 | 6.07 | 6.65 |
| 25 | 1 | 2 | 2 | 2 | 2 | 5 | 5 | 10 | 6 | 9 | 8 | 1 | 53 | 7.45 | 7.00 | 7.21 |
| 26 | 1 | 2 | 2 | 3 | 5 | 2 | 8 | 14 | 9 | 5 | 6 | .. | 57 | 8.66 | 7.52 | 8.06 |
| 27 | .. | 1 | 2 | 4 | 4 | 7 | 5 | 11 | 3 | 5 | 4 | 1 | 47 | 8.97 | 6.20 | 7.49 |
| 28 | 1 | 8 | 1 | 2 | .. | 6 | 6 | 6 | 4 | 5 | 2 | .. | 41 | 8.36 | 5.41 | 6.79 |
| 29 | 1 | 1 | .. | 6 | 5 | 11 | 3 | 6 | 1 | 2 | 1 | .. | 37 | 7.14 | 4.88 | 5.94 |
| 30 | .. | 4 | .. | 4 | 3 | 6 | 4 | 4 | 1 | 4 | 2 | .. | 32 | 7.14 | 4.22 | 5.59 |
| 31 | 1 | 2 | 3 | 8 | 1 | 3 | 5 | 4 | 1 | 4 | .. | .. | 32 | 7.90 | 4.22 | 5.94 |
| 32 | 5 | .. | 1 | 8 | 2 | 2 | 2 | 3 | 2 | .. | .. | .. | 25 | 6.23 | 3.30 | 4.67 |
| 33 | .. | 2 | .. | 12 | 6 | 7 | 3 | 1 | .. | .. | .. | .. | 31 | 7.45 | 4.09 | 5.66 |
| 34 | .. | 1 | 1 | 8 | 2 | 3 | .. | 1 | .. | .. | .. | .. | 16 | 5.02 | 2.11 | 3.46 |
| 35 | 2 | 1 | 1 | 4 | 5 | .. | 1 | .. | .. | .. | 1 | .. | 15 | 1.67 | 1.98 | 1.84 |
| 36 | 1 | 2 | 1 | 2 | 1 | 1 | .. | .. | .. | .. | .. | .. | 8 | 1.22 | 1.06 | 1.13 |
| 37 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .15 | .00 | .07 |
| 38 | .. | .. | .. | 1 | .. | .. | 1 | .. | .. | .. | .. | .. | 2 | .46 | .26 | .35 |
| 39 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .15 | .00 | .07 |
| 40 | .. | 1 | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 2 | .15 | .26 | .21 |
| 41 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .00 | .... | .00 |
| 42 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .15 | .... | .07 |
| | 36 | 37 | 23 | 88 | 60 | 92 | 64 | 123 | 64 | 83 | 83 | 4 | 757 | | | |

## TABLE C.

DISK-FLORETS.

| No. | September, 1903 | | | | | | | | | October, 1903 | | | Total 1903 | 1900 in % | 1903 in % | Sum in % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 14 | 16 | 18 | 21 | 23 | 25 | 28 | 30 | 2 | 6 | 9 | | | | |
| 14 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 1 | .... | .13 | .07 |
| 15 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .... | .00 | .00 |
| 16 | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 1 | .... | .13 | .07 |
| 17 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .... | .13 | .07 |
| 18 | .. | .. | 1 | .. | .. | .. | .. | 1 | .. | .. | .. | .. | 2 | .... | .26 | .14 |
| 19 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .... | .00 | .00 |
| 20 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | 2 | .... | .26 | .14 |
| 21 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .... | .13 | .07 |
| 22 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .... | .00 | .00 |
| 23 | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 1 | .. | 2 | .... | .26 | .14 |
| 24 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | 1 | .... | .13 | .07 |
| 25 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | 2 | .15 | .26 | .21 |

TABLE C (*continued*).

| No. | September, 1903 | | | | | | | | | October, 1903 | | | Total 1903 | 1900 in % | 1903 in % | Sum in % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 14 | 16 | 18 | 21 | 23 | 25 | 28 | 30 | 2 | 6 | 9 | | | | |
| 21 | .. | .. | .. | .. | .. | .. | 1 | .. | 2 | .. | 1 | .. | 4 | .00 | .53 | .28 |
| 27 | .. | .. | .. | .. | .. | 1 | .. | 2 | .. | 1 | .. | .. | 4 | .00 | .53 | .28 |
| 28 | 1 | .. | .. | .. | 2 | .. | .. | 1 | .. | .. | 3 | .. | 7 | .00 | .92 | .49 |
| 29 | 1 | .. | .. | .. | .. | 2 | .. | .. | 1 | 1 | 4 | .. | 9 | .00 | 1.19 | .64 |
| 30 | 3 | .. | .. | .. | 1 | .. | .. | .. | .. | 1 | 5 | .. | 10 | .00 | 1.32 | .71 |
| 31 | 2 | .. | .. | .. | 2 | 1 | 1 | 3 | .. | 1 | 1 | .. | 11 | .15 | 1.45 | .85 |
| 32 | .. | .. | .. | .. | 2 | 3 | 1 | 3 | .. | .. | 1 | .. | 10 | .15 | 1.32 | .78 |
| 33 | 1 | 1 | .. | .. | 1 | .. | .. | 2 | .. | 5 | 2 | .. | 12 | .15 | 1.58 | .92 |
| 34 | 1 | .. | .. | 4 | .. | 2 | .. | 1 | 3 | 1 | 3 | .. | 15 | .46 | 1.98 | 1.27 |
| 35 | 3 | 1 | .. | 1 | 1 | 2 | 1 | 5 | 2 | 4 | 9 | 1 | 30 | .15 | 3.96 | 2.19 |
| 36 | .. | 1 | .. | 2 | 1 | 2 | 1 | 4 | 1 | 4 | 5 | .. | 21 | .00 | 2.77 | 1.48 |
| 37 | 2 | .. | 2 | 1 | 5 | 2 | 1 | 4 | 3 | 3 | 6 | .. | 29 | .46 | 3.83 | 2.26 |
| 38 | 3 | .. | .. | 2 | 1 | 1 | 3 | 4 | 3 | 6 | 4 | .. | 27 | .46 | 3.56 | 2.12 |
| 39 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 5 | 3 | 5 | 1 | .. | 30 | .61 | 3.96 | 2.40 |
| 40 | 2 | 1 | .. | 2 | 2 | 2 | 1 | 5 | .. | 4 | 4 | .. | 23 | 1.98 | 3.04 | 2.55 |
| 41 | 1 | .. | .. | 2 | 1 | 2 | 2 | 8 | 3 | 4 | 5 | 2 | 30 | 1.22 | 3.96 | 2.69 |
| 42 | .. | 2 | 1 | 4 | .. | 5 | 2 | 9 | 4 | 6 | 3 | .. | 36 | 2.28 | 4.75 | 3.61 |
| 43 | 2 | 1 | .. | 2 | 1 | 4 | .. | 6 | 2 | 2 | 2 | .. | 22 | 4.10 | 2.90 | 3.46 |
| 44 | .. | .. | .. | .. | 1 | 5 | 1 | 6 | 6 | 2 | 4 | 1 | 26 | 3.50 | 3.43 | 3.46 |
| 45 | .. | 1 | 4 | 3 | 2 | 4 | 3 | 3 | 7 | 4 | 4 | .. | 35 | 5.78 | 4.62 | 5.16 |
| 46 | .. | 2 | 1 | 1 | 2 | 2 | 2 | 5 | 1 | 9 | 1 | .. | 26 | 6.54 | 3.43 | 4.88 |
| 47 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 4 | 2 | 7 | 2 | .. | 32 | 5.32 | 4.22 | 4.74 |
| 48 | .. | .. | .. | 3 | .. | 7 | 2 | 4 | 6 | 2 | 1 | .. | 25 | 5.93 | 3.30 | 4.52 |
| 49 | .. | 3 | .. | 3 | 3 | 1 | 2 | 5 | 2 | 4 | 2 | .. | 25 | 7.14 | 3.30 | 5.09 |
| 50 | .. | 1 | 2 | 1 | 2 | 2 | 3 | 9 | 4 | 3 | 4 | .. | 31 | 7.14 | 4.09 | 5.51 |
| 51 | .. | 1 | 1 | 5 | 2 | 4 | 2 | 3 | 1 | .. | 1 | .. | 20 | 5.47 | 2.64 | 3.96 |
| 52 | 1 | 1 | .. | 4 | .. | 4 | 1 | 5 | 2 | .. | 1 | .. | 19 | 6.84 | 2.51 | 4.52 |
| 53 | .. | 1 | 1 | 3 | 2 | 2 | 4 | 5 | .. | 3 | .. | .. | 21 | 6.38 | 2.77 | 4.45 |
| 54 | .. | .. | .. | 2 | 1 | 4 | 5 | 2 | 1 | .. | 1 | .. | 16 | 4.86 | 2.11 | 3.39 |
| 55 | 1 | 3 | .. | 2 | 4 | 3 | 5 | 5 | .. | .. | .. | .. | 23 | 3.95 | 3.04 | 3.46 |
| 56 | 1 | 3 | 1 | 4 | 6 | 3 | 3 | 2 | .. | .. | .. | .. | 23 | 4.56 | 3.04 | 3.75 |
| 57 | .. | .. | .. | 3 | 3 | 8 | 2 | 1 | 1 | .. | .. | .. | 18 | 2.74 | 2.38 | 2.55 |
| 58 | .. | 1 | 2 | 6 | 2 | 1 | 4 | 1 | 1 | .. | .. | .. | 18 | 2.13 | 2.38 | 2.26 |
| 59 | 2 | .. | 1 | 5 | 1 | 4 | 2 | .. | .. | .. | .. | .. | 15 | 1.67 | 1.98 | 1.84 |
| 60 | 1 | 1 | .. | 4 | 3 | 1 | .. | .. | .. | .. | .. | .. | 10 | 2.13 | 1.32 | 1.70 |
| 61 | 1 | .. | .. | 2 | .. | 1 | .. | .. | .. | .. | .. | .. | 4 | 1.37 | .53 | .92 |
| 62 | .. | .. | .. | 3 | 1 | .. | 1 | .. | .. | .. | .. | .. | 5 | 1.22 | .66 | .92 |
| 63 | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | 1 | .61 | .13 | .35 |
| 64 | 2 | .. | 1 | 2 | 1 | .. | 1 | .. | .. | .. | .. | .. | 7 | .00 | .02 | .49 |
| 65 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1.06 | .13 | .57 |
| 66 | .. | .. | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | 2 | .46 | .26 | .35 |
| 67 | .. | 1 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | 3 | .00 | .40 | .21 |
| 68 | .. | .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. | .. | 3 | .30 | .40 | .35 |
| 69 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .15 | .00 | .07 |
| 70 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 71 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 72 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 73 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .15 | .13 | .14 |
| 74 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | .15 | .26 | .21 |
| 75 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 76 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 77 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 | .00 | .00 | .00 |
| 78 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | .00 | .26 | .14 |
| 79 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .15 | .... | .07 |
| | 36 | 37 | 23 | 88 | 60 | 92 | 64 | 123 | 64 | 83 | 83 | 4 | 757 | | | |

TABLE D.

CHIEF CONSTANTS OF THE SEVERAL COLLECTIONS.

| Bracts | Sep. 12 | Sep. 14 | Sep. 16 | Sep. 18 | Sep. 21 | Sep. 23 | Sep. 25 | Sep. 28 | Sep. 30 | Oct. 2 | Oct. 6 | Oct. 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean..... | 36.555 | 43.297 | 43.174 | 43.898 | 40.700 | 40.652 | 39.828 | 37.423 | 36.016 | 35.120 | 33.096 | 35.750 |
| P. E. M.... | ± 1.110 | ± .868 | ± .947 | ± .500 | ± .723 | ± .402 | ± .508 | ± .401 | ± .543 | ± .423 | ± .389 | ± .935 |
| σ ..... | 9.870 | 7.829 | 6.735 | 6.951 | 8.303 | 7.002 | 7.090 | 6.598 | 6.438 | 5.717 | 5.247 | 2.773 |
| P. E. σ ... | ± .785 | ± .614 | ± .670 | ± .353 | ± .511 | ± .348 | ± .423 | ± .284 | ± .384 | ± .299 | ± .275 | ± .661 |
| C. V..... | 27.000 | 18.081 | 15.600 | 15.835 | 20.401 | 17.225 | 17.801 | 17.630 | 17.877 | 16.278 | 15.854 | 7.756 |
| P. E. V.... | ± 2.146 | ± 1.418 | ± 1.551 | ± .805 | ± 1.256 | ± .857 | ± 1.061 | ± .758 | ± 1.066 | ± .852 | ± .830 | ± 1.849 |

Rays

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean..... | 23.305 | 27.540 | 26.739 | 28.681 | 26.600 | 26.033 | 26.187 | 24.179 | 24.109 | 23.880 | 22.301 | 24.500 |
| P. E. M.... | ± .720 | ± .582 | ± .669 | ± .380 | ± .485 | ± .326 | ± .392 | ± .249 | ± .342 | ± .272 | ± .278 | ± .550 |
| σ ..... | 6.407 | 5.248 | 4.757 | 5.284 | 5.571 | 4.628 | 4.650 | 4.092 | 4.058 | 3.668 | 3.757 | 1.658 |
| P. E. σ ... | ± .509 | ± .412 | ± .473 | ± .269 | ± .343 | ± .230 | ± .277 | ± .176 | ± .242 | ± .192 | ± .197 | ± .396 |
| C. V..... | 27.490 | 19.158 | 17.790 | 18.423 | 20.945 | 17.780 | 17.756 | 16.926 | 16.834 | 15.361 | 16.846 | 6.769 |
| P. E. V.... | ± 2.185 | ± 1.494 | ± 1.769 | ± .937 | ± 1.290 | ± .884 | ± 1.059 | ± .728 | ± 1.004 | ± .804 | ± .882 | ± 1.614 |

Disk-florets

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean..... | 41.611 | 51.729 | 46.522 | 51.511 | 47.100 | 46.891 | 47.672 | 43.569 | 42.187 | 41.301 | 38.072 | 40.250 |
| P. E. M.... | ± 1.282 | ± 1.318 | ± 1.343 | ± .724 | ± .862 | ± .603 | ± .813 | ± .459 | ± .682 | ± .469 | ± .535 | ± 1.103 |
| σ ..... | 11.405 | 11.884 | 9.546 | 10.062 | 9.899 | 8.569 | 9.647 | 7.539 | 8.087 | 6.330 | 7.219 | 3.269 |
| P. E. σ ... | ± .907 | ± .932 | ± .949 | ± .512 | ± .610 | ± .426 | ± .575 | ± .324 | ± .482 | ± .332 | ± .378 | ± .780 |
| C. V..... | 27.408 | 22.973 | 20.519 | 19.534 | 21.017 | 18.274 | 20.236 | 17.303 | 19.170 | 15.349 | 18.062 | 8.122 |
| P. E. V.... | ± 2.179 | ± 1.801 | ± 2.041 | ± .993 | ± 1.294 | ± .909 | ± 1.206 | ± .744 | ± 1.143 | ± .804 | ± .993 | ± 1.937 |

In Table D are given the more important constants of the several collections with the probable errors of the determination. The average deviation is omitted as having no significance, since the probable error of the determination is almost as large as the determined value of the constant. It will be noted on examining this table that all the constants are quite variable, and that only the mean seems to follow a rather definite law, beginning low, then leaping almost immediately to the maximum, after which there is a gradual fall until almost the end, when a slight rise appears. The fall of mean values from the maximum on September 18 to the minimum on October 6 was 24.6 per cent. in bracts, 22.25 per cent. in rays, and 26.4 per cent. in disk-florets. The changes of mean value for each set of variants from the beginning to the end of the flowering season and the corresponding changes observed in 1900 are shown graphically in *fig.* 7.

1. *Bracts.*—The frequency polygon for the bracts is shown in *fig. 8.* The mean value is $38.597 \pm .189$, and a number of empirical modes are present. Some, if not all, of these are doubtless due to the smallness of the number of heads counted. It will be noted

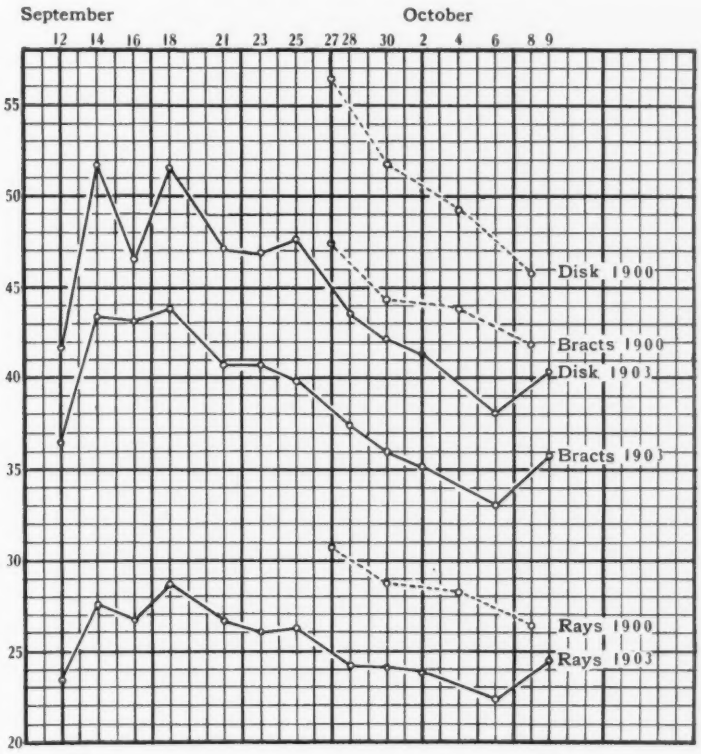



FIG. 7.—Curves showing the changes in the mean numbers of parts in the heads from the beginning to the end of the season, and the difference between the two collections, 1900 and 1903.

that the most prominent modes are those which lie below the mean value; *i. e.*, if one may speak of skewness in multimodal curves, there is evident here a strong positive skewness. The breadth of the curve exhibits to the eye the great variability, which may be expressed

numerically by the standard deviation 7.692±.133, or by the coefficient of variability 19.928±.345.

2. *Rays.*—The ray-curve shown in *fig. 9* has the mean at 25.247 ±.122 and by much the strongest mode at 22, so that here again there is a very prominent skewing of the curve. The empirical

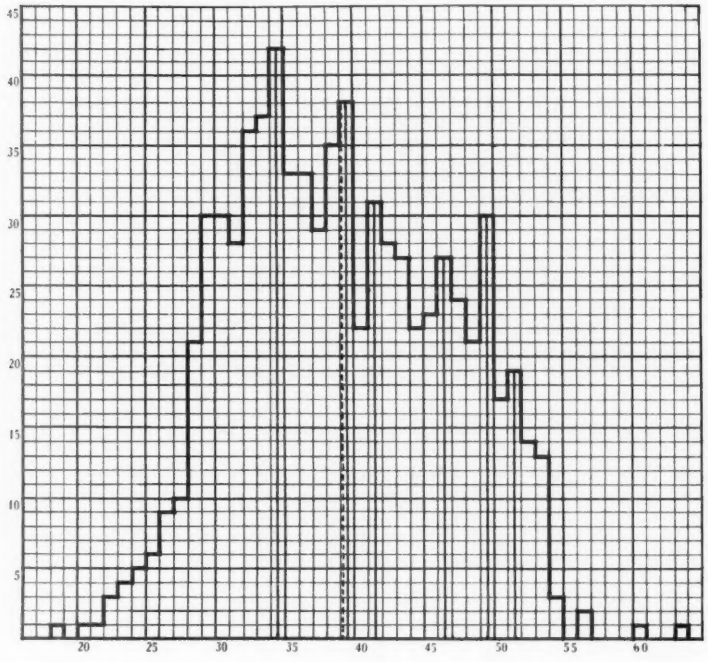



FIG. 8.—Bract-curve for 757 heads collected in 1903: mean 38.597±.189; empirical modes 29–30, 34, 39, 41, 46, 49, 51; $\sigma = 7.692 \pm .133$.

modes at 16, 22, 26, 33 are somewhat suggestive of the series which LUDWIG, DE VRIES, and others have shown to be so common, but aside from such suggestion can have little meaning. The standard deviation 4.990±.087 is considerably less than that of the bracts, while the coefficient of variability, 19.764±.344, is practically the same.

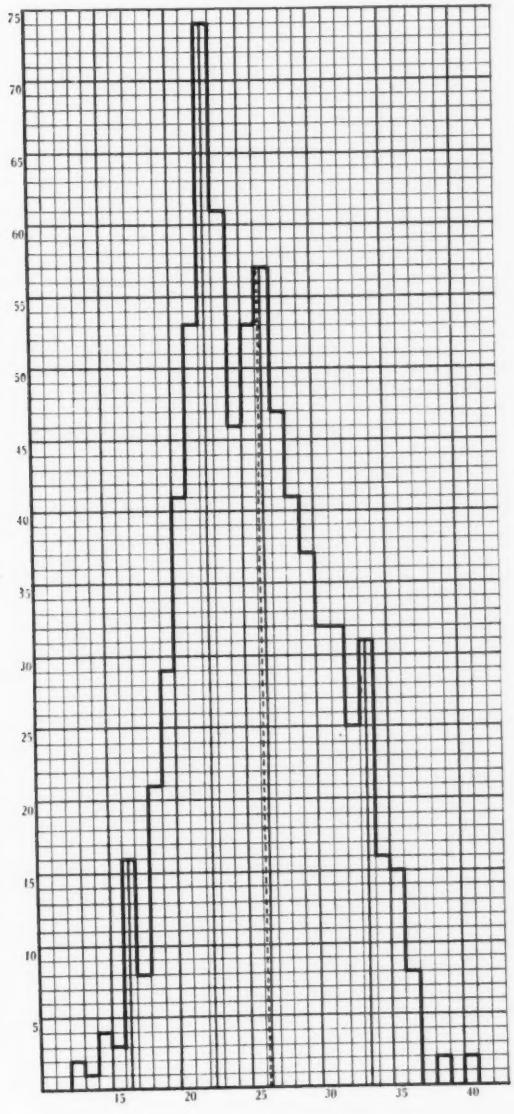



FIG. 9.—Ray-curve for 757 heads collected in 1903: mean $25.247 \pm .122$; empirical modes 16, 22, 26, 33; $\sigma = 4.9899 \pm .0865$.

3. *Disk-florets.*—The polygon of distribution of the disk-florets is presented in *fig. 10.* The range, from 14 to 78, is so wide that 757 heads are quite insufficient to make the many empirical modes of any

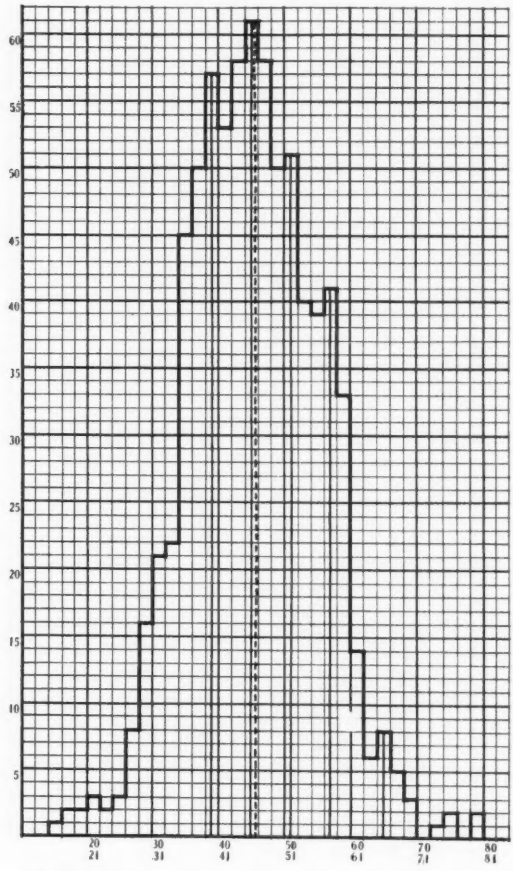



FIG. 10.—Disk-floret curve for 757 heads collected in 1903: classes doubled; mean 44.933± .238; empirical modes 38–39, 44–45, 50–51, 56–57, 64–65; $\sigma$=9.703 ± .168.

significance. To make the curve comparable with that offered by the disk-florets in 1900, the classes were doubled, but this still leaves

five prominent modes. The positive skewness is not so marked as in the bracts and rays, but inspection of the curve will show plainly that the theoretical mode is below the mean, though the principal apparent mode nearly coincides with the mean. The standard deviation is $9.703 \pm .168$ and the coefficient of variability $21.595 \pm .374$.

4. *Summation, 1900 and 1903.*—The more important constants for bracts, rays, and disk-florets are given in Tables E, F, and G, along with the corresponding data for 1900 and the summation of the two lots. The summation-curves of bracts, rays, and disk-

TABLE E.

CONSTANTS OF BRACTS FOR 1900, 1903, AND THEIR SUM.

| | 1900 | 1903 | Combined |
|---|---|---|---|
| Number | 658 | 757 | 1415 |
| Mean | 44.044 | 38.597 | 41.130 |
| P. E.$_M$ | ± .150 | ± .189 | ± .131 |
| Modes, empirical | 34, 39, 43, 49 | 29–30, 34, 39, 41, 46, 49, 51 | 30, 32, 34, 39, 41, 43, 49 |
| $\sigma$ | 5.717 | 7.692 | 7.313 |
| P. E.$_\sigma$ | ± .106 | ± .133 | ± .093 |
| C. V. | 12.979 | 19.928 | 17.775 |
| P. E.$_v$ | ± .241 | ± .345 | ± .225 |

TABLE F.

CONSTANTS OF RAYS FOR 1900, 1903, AND THEIR SUM.

| | 1900 | 1903 | Combined |
|---|---|---|---|
| Number | 658 | 757 | 1415 |
| Mean | 28.038 | 25.247 | 26.545 |
| P. E.$_M$ | ± .107 | ± .122 | ± .086 |
| Modes, empirical | 27, 31, 33 | 16, 22, 26, 33 | 16, 22, 26, 31, 33 |
| $\sigma$ | 4.070 | 4.990 | 4.792 |
| P. E.$_\sigma$ | ± .076 | ± .087 | ± .061 |
| C. V. | 14.516 | 19.764 | 18.052 |
| P. E.$_v$ | ± .270 | ± .344 | ± .229 |

florets, together with the two partial curves of which each is composed, are shown in *figs. 11, 12,* and *13*. These curves are all reduced to the same area, 500 units, in order to facilitate comparison, and the method of "loaded ordinates" is used to allow the curves to be superposed.

The bracts for the two years combined present no less than seven empirical modes, showing without question that 1415 heads is still too few for material having so wide a range and so high standard deviation. In the rays, the range being less and the standard devia-

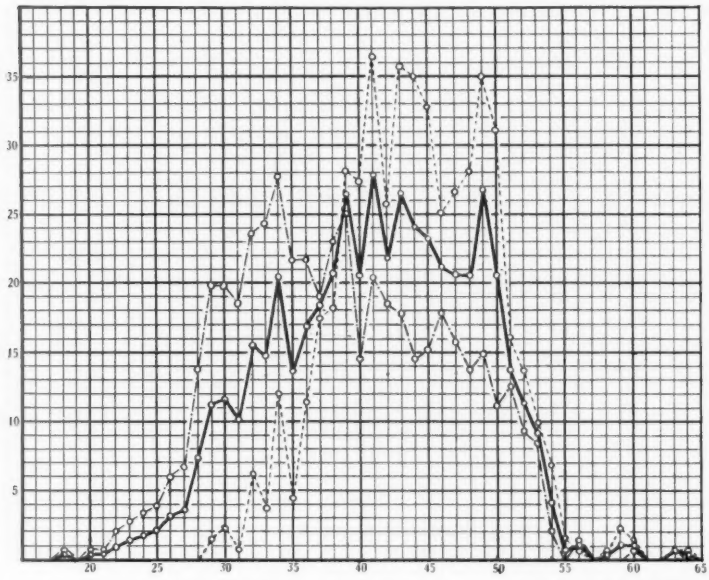



FIG. 11.—Summation curve for bracts 1900+1903 and the bract-curves for 1900 and 1903 superposed for comparison; all reduced to the same area, 500 units; heavy line the summation curve; dotted line the 1900 curve; dot and dash line the 1903 curve.

TABLE G.

CONSTANTS OF DISK-FLORETS FOR 1900, 1903, AND THEIR SUM.

| | 1900 | 1903 | Combined |
|---|---|---|---|
| Number | 658 | 757 | 1415 |
| Mean | 50.298 | 44.933 | 47.428 |
| P. E. M | ± .166 | ± .238 | ± .156 |
| Modes, empirical | 48–49, 52–53 | 38–39, 44–45, 50–51, 56–57, 64–65 | 49–50 |
| σ | 6.310 | 9.703 | 8.724 |
| P. E. σ | ± .117 | ± .168 | ± .111 |
| C. V | 12.546 | 21.595 | 18.395 |
| P. E. V | ± .233 | ± .374 | ± .233 |

tion only two-thirds as great, the number of heads is much more nearly adequate. There are presented five empirical modes, 16, 22, 26, 31, 33, almost in agreement with LUDWIG's series.

5. *Correlations.*—The correlation between rays and bracts is shown in *fig. 14*, between rays and disk-florets in *fig. 15*, and between

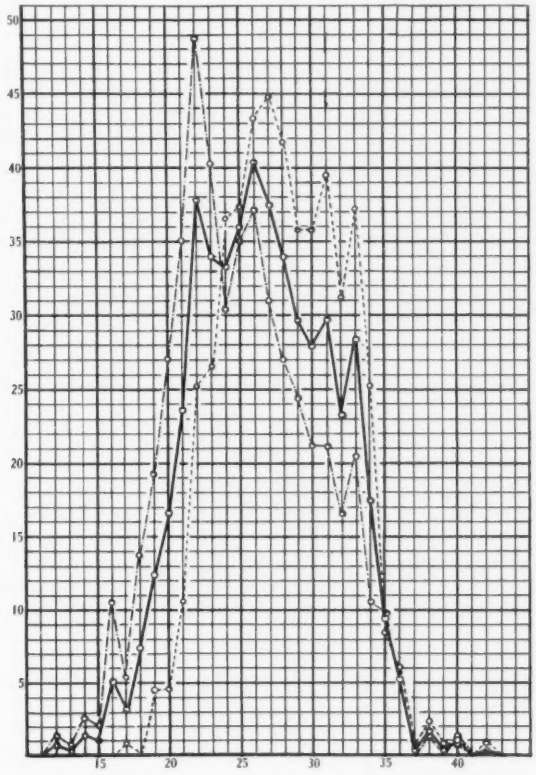



FIG. 12.—Summation curve for rays 1900 + 1903 and the ray-curves for 1900 and 1903 superposed for comparison; all reduced to the same area, 500 units; heavy line the summation curve; dotted line the 1900 curve; dot and dash line the 1903 curve.

bracts and disk-florets in *fig. 16*. The coefficient of correlation is very high in all, being greatest between rays and bracts, and least between rays and disk-florets. The coefficients may be compared with those of 1900 in Table H:

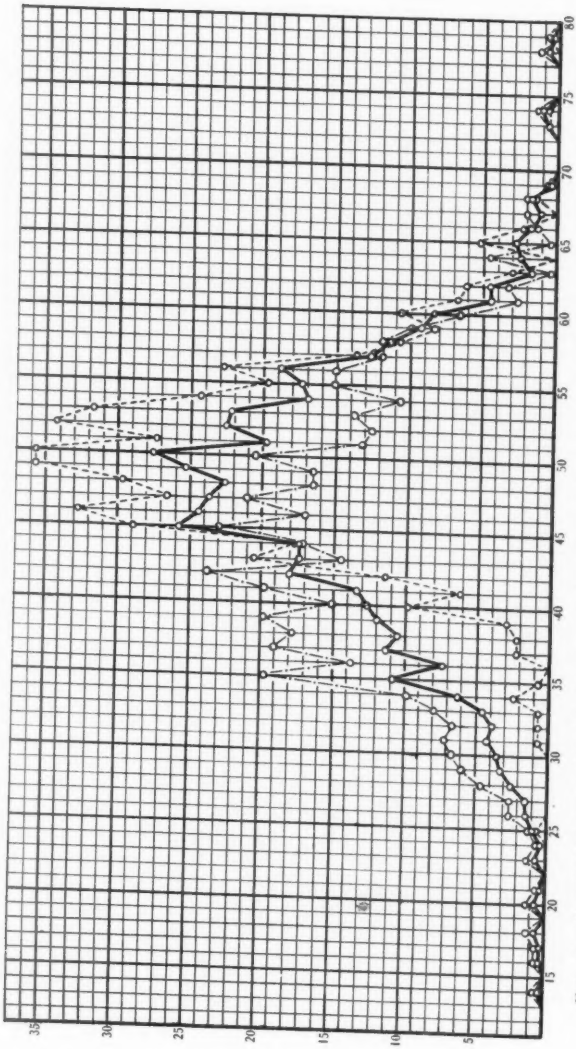



FIG. 13.—Summation curve for disk-florets 1900 + 1903 and the disk-floret curves for 1900 and 1903 superposed for comparison; all reduced to the same area, 500 units; heavy line the summation curve; dotted line the 1900 curve; dot and dash line the 1903 curve.

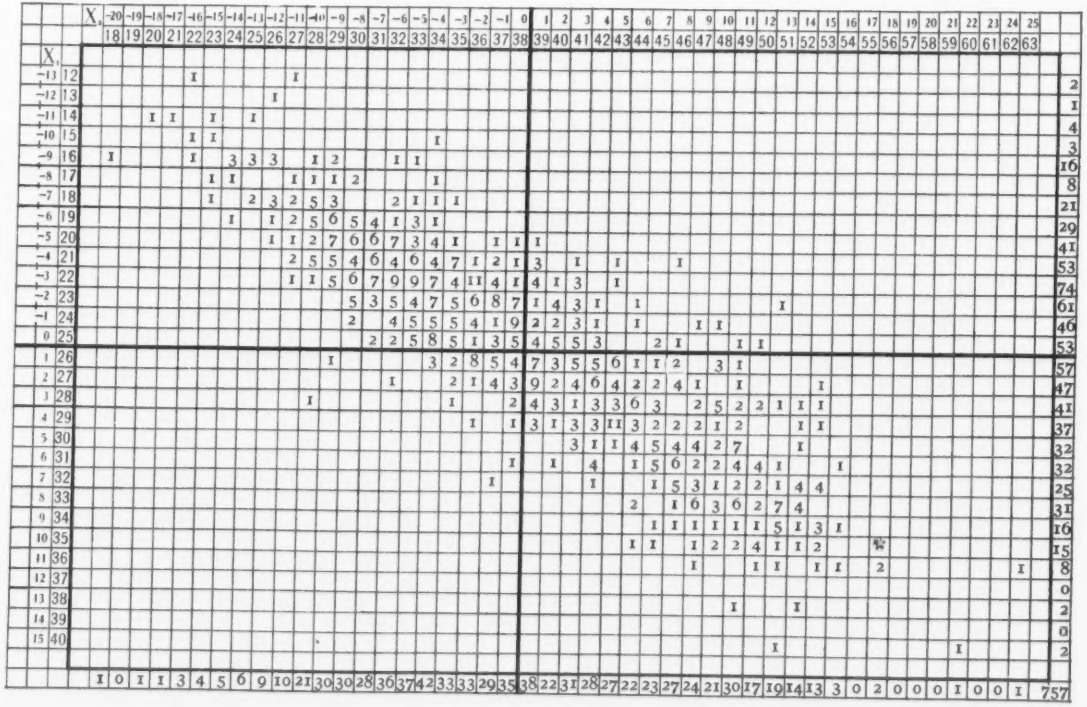


FIG. 14.—Correlation surface for 757 heads collected in 1903; rays subject, bracts relative; $\rho = .8745 \pm .0042$.

TABLE H.

COEFFICIENTS OF CORRELATION.

| | 1900 | 1903 |
|---|---|---|
| Rays and bracts | .7051 ± .0092 | .8745 ± .0042 |
| Rays and disk-florets | .6749 ± .0100 | .8240 ± .0058 |
| Bracts and disk-florets | ..... | .8355 ± .0055 |

## V. DISCUSSION.

In my earlier study the conclusion was reached that the mean number of parts in the heads of *Aster prenanthoides* begins high and falls continuously from the beginning to the end of the flowering season. This was recognized as in accord with BURKILL's (1895) results on *Alsine media* and other species. REINÖHL (1903) has recently made a very careful study of *Alsine media* and reports that the first flowers never have the highest number of stamens and that the maximum number is reached only after some time. He attributes BURKILL's results to the fact that they were based upon occasional collections which, he supposes, did not happen to involve the very earliest flowers of the season. My collections of *Aster prenanthoides* in 1900 included all the heads which bloomed that year, but the first collection was made so late that the mean numbers of parts in the very earliest heads were indeterminable because of their association with heads of later development; but in 1903 the collections were made with such frequency as more closely to analyze the changes taking place during the season, there being presented here twelve successive collections instead of four.

It is now shown that in *Aster prenanthoides* also the mean numbers begin low, leaping almost immediately to the maximum, and thence falling more gradually till near the end of the season. Inspection of *fig.* 7 will make it clear that four collections in 1903, made on the same dates as the 1900 collections, would have led to the conclusions then reached that there is a continuous fall from the beginning to the end of the season.

It will be noted in the same figure that the last collection in 1903 shows a rise in mean values. As this collection consisted of but four heads, it can be considered as having little significance. I believe, however, that this condition will be found to occur not infrequently.

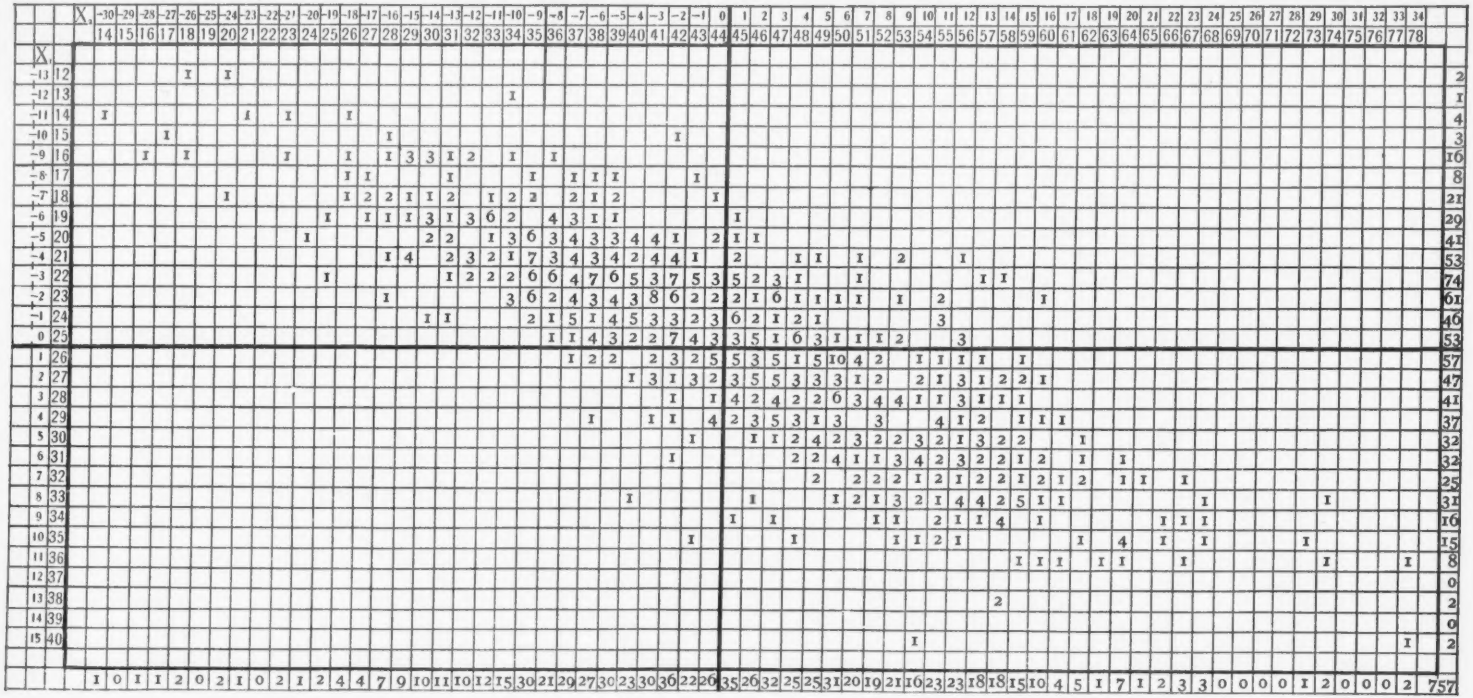
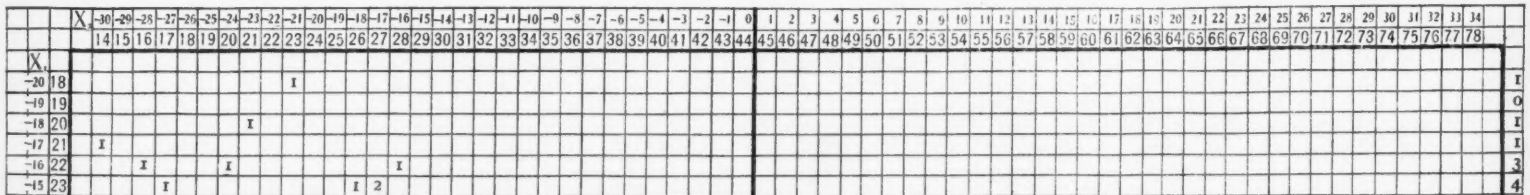


FIG. 15.—Correlation surface for 757 heads collected in 1903; rays subject, disk-florets relative; $\rho = .8240 \pm .0058$.



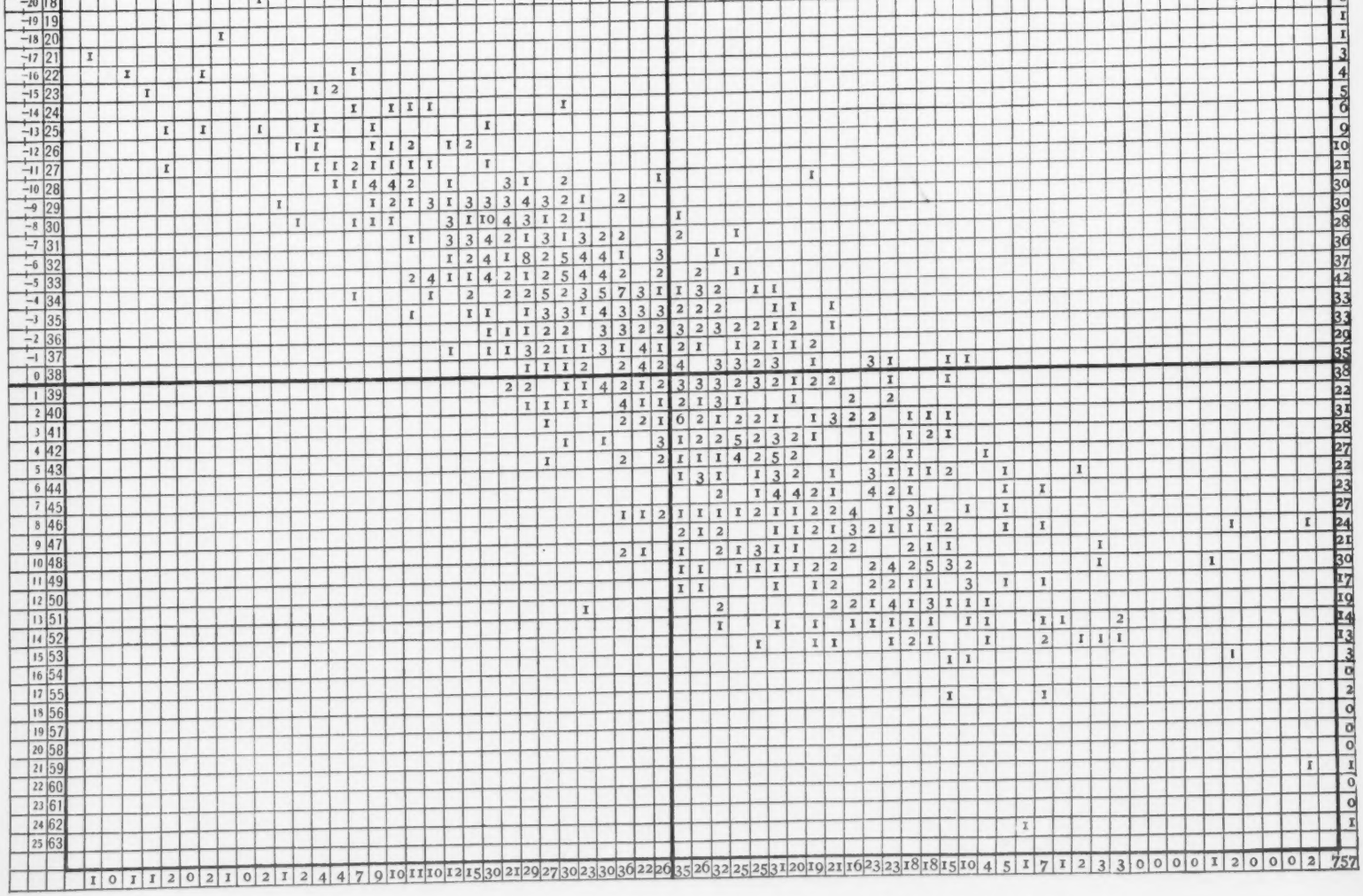
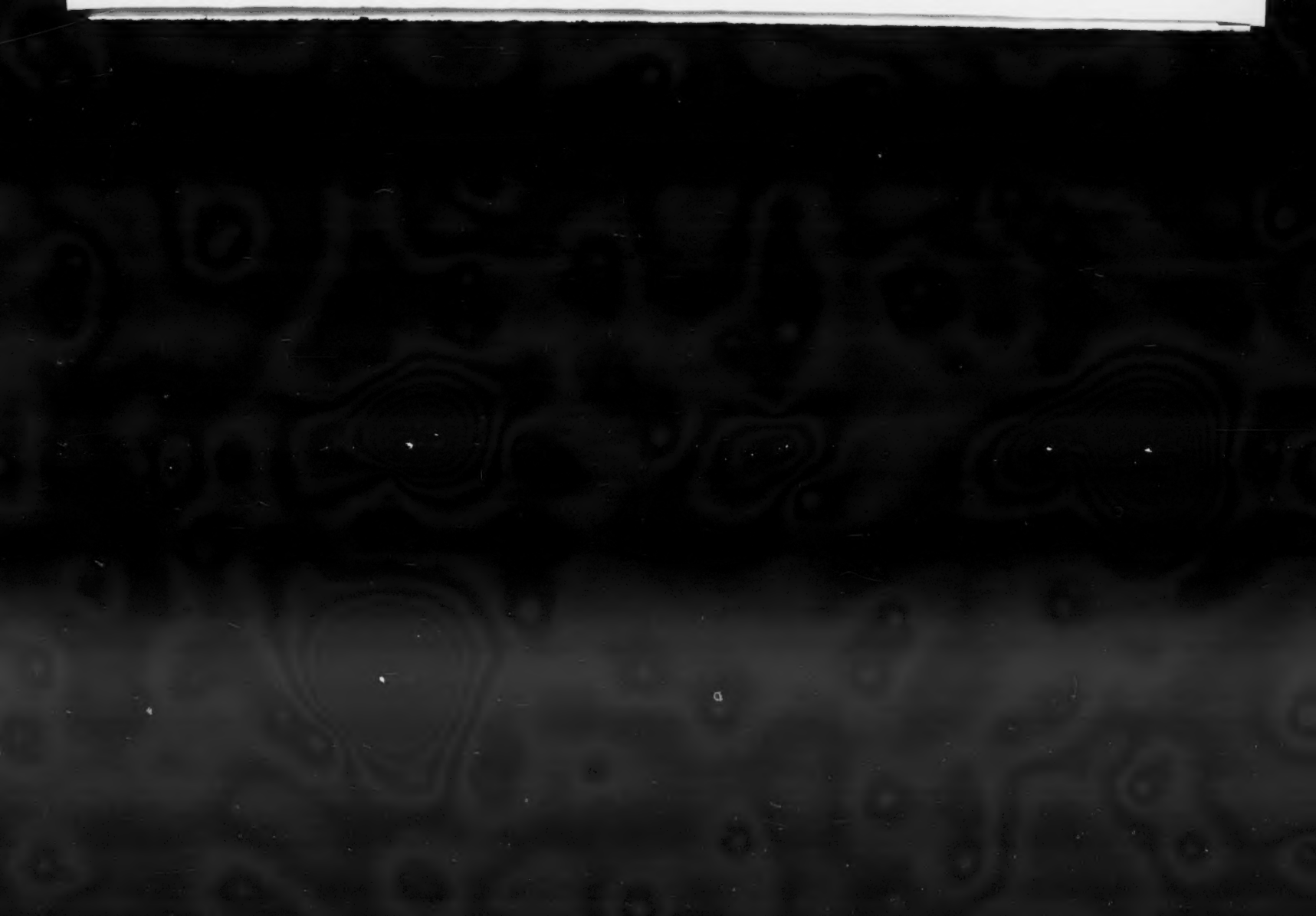


FIG. 16.—Correlation surface for 757 heads collected in 1903; bracts subject, disk-florets relative; $\rho = .8355 \pm .0055$.



It was observed by BURKILL (1902) in *Ranunculus arvensis* L., but he did not "feel justified in suggesting a cause for it." BURKILL (1895) showed in his earlier paper that in *Caltha palustris*, *Ranunculus arvensis*, and *R. bulbosus* the first flower of any individual has a higher number of stamens than any subsequent flower of that individual. HAACKE (1896) points out the same fact in regard to the number of rays in the heads of *Tanacetum* (*Chrysanthemum*) *corymbosum*. If this is also true in *Aster prenanthoides* (and I believe it is), how are we to account for the peculiarities of the curves in *fig. 7*? The general fall in mean values from near the beginning to near the end of the flowering period can be best explained perhaps by the gradual waning of vegetative vigor during the time at which the differentiation takes place which determines the number of parts in the heads. This decreasing vigor was supposed by BURKILL (1895) to be largely due to changing temperature, but REINÖHL (1903) has shown that temperature has little if any influence, while the important factor seems to him to be that of available food-supply. It is conceivable that there may be a decreasing lability of the protoplasm resulting from lessened water-supply, or the accumulation of inert products of metabolism, or from other causes, which would bring about a progressive fall in the number of parts in the heads, even though the food-supply remained unchanged.

But if every individual produces the highest number of parts in the first head that blooms and the lowest number of parts in the last, how can the mean number begin low—far below the maximum—and end with a rise? This is to be explained by the fact that we are dealing with a population instead of an individual. The precocious flowering of starved or otherwise weakened individuals is a well-known phenomenon, and it is evident that the heads gathered at the first collection were those produced by the very weakest individuals, and owe their low values to that fact. Very soon, however, the mediocre plants, composing the great majority of the population, begin to bloom, thus bringing the mean values at once to the maximum, from which they gradually fall until almost the end of the season. The very last to bloom will undoubtedly be the last heads of certain very vigorous individuals which did not begin to bloom till late in the season, and though these heads have the lowest numbers of parts produced

by those individuals, they yet have higher numbers than the last heads of the mediocre portion of the population which determined the minimum mean value. These facts will be made clear by a reference to *fig.* 17, in which the numerous oblique parallel lines represent the change in mean number of parts in the heads of the individual stems composing the population. The abscissal distances of the ends of a given line indicate the time at which the individual represented by that line began to bloom and that at which it ceased blooming, while the ordinatal distances of the same points represent the number of parts in the first and last heads produced. The heavy line running through the middle of the figure is the exact mean of the figure as drawn. This figure is somewhat schematic, of course, but it is not wholly imaginary. The mean is suggested by the 1903 bract-curve of *fig.* 7, and the outline will be recognized in the distribution of numbers in Table A, which also belongs to the bracts of the 1903 population, so that *fig.* 17 may be looked upon as a slightly schematized representation of the bracts as they actually occurred in 1903.

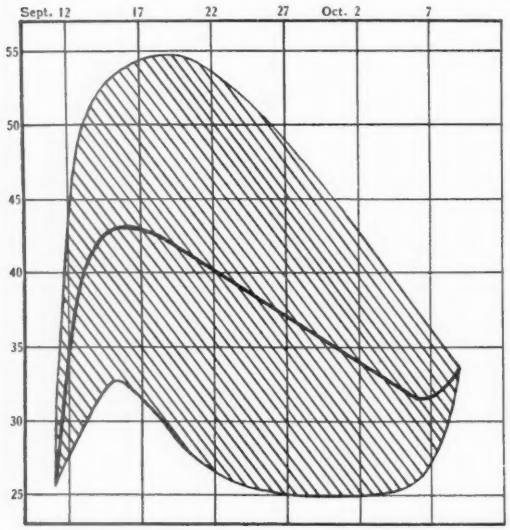



FIG. 17. — Schematized representation of the changes in mean number of parts in the heads of the 1903 population; each of the parallel oblique lines represents the change in a single stem; the heavy line shows the change in mean value for the whole population.

In 1900 the change in mean values from the maximum to the minimum was 11.6 per cent. in bracts, 14.4 per cent. in rays, and 18.9 per cent. in disk-florets; and in 1903 it was 24.6 per cent. in bracts, 22.3 per cent. in rays, and 26.4 per cent. in disk-florets. This con-

siderable change in the constants of variable characters during the single season is now generally recognized, as has been made manifest in the discussions which were roused by LUDWIG'S (1901) interpretation of such differences as indicative of the establishment of local races or *petites espèces*. Miss LEE (1902) says in her discussion of LUDWIG'S results and conclusions, "we require in fact to know how the means, variabilities, and correlations of the characters of a plant change (i) with its season and (ii) with the influence of environment before we can formulate a test for racial differences," and PEARSON (1903) and other recent writers make similar statements.

While there is thus a general recognition of the changes which may be expected to take place during a single season, there is still a question as to changes of variability from season to season. This is the first investigation in which factors involved in modifying the variable characters of plants or animals have been so completely limited to the dissimilarity of different seasons. Although a number of students have at times found differences similar to those presented in this paper, their material has been collected nearly always in such a way as to allow of some other interpretation, and the conclusions arrived at have in consequence usually assumed the absence of seasonal fluctuations.

YULE (1902) has investigated the number of sepals of *Anemone nemorosa* growing in several different habitats in the neighborhood of Bookham, Surrey, England, during the years 1889–1900, but unfortunately his collections were not made at coincident dates of the several years, and one of the habitats had changed during the time in which the observations were made from an exposed clearing to a well-grown shady copse. Although he interprets his results as indicating a considerable fluctuation from season to season, his data can be thrown into a single series and shown to exhibit just the changes which recent investigations of REINÖHL (1903) on *Alsine media* and the results recorded here for *Aster prenanthoides* show to occur during a single season. Thus, taking YULE'S data for habitat (C), which he describes as a narrow strip of copse at Little Bookham, and arranging them according to the time of year at which each collection was made, without regard to the year, we have for the mean number of sepals: April 8–12, 1899, 6.63; April 15,

1900, 6.81; April 21–22, 1898, 6.76; May 7, 1898, 6.51. A comparison of these results with the curves in *fig.* 7 will show them to be strictly comparable with the conditions exhibited by *Aster prenanthoides* in the single season of 1903. They differ, however, in being much less striking, the greatest change of mean value in *Anemone nemorosa* being only 4.4 per cent., while the greatest change in mean value in *Aster prenanthoides* was 26.4 per cent.

The Clifton area of *Aster prenanthoides* is in a perfectly natural condition, and though the region is much visited for its fine scenery, this particular spot, being less attractive to tourists and at the same time more difficult of access, is not likely to be at any time seriously disturbed. It can be assumed with perfect assurance that there were no appreciable differences in the habitat in the two years 1900 and 1903, except such as were due to meteorological differences, and to these factors or possibly to internal periodicity, or a combination of these internal causes and climatic changes must be attributed the great differences found.

It has not been infrequent to find great differences in variable characters of plants from markedly different habitats, as in the daisies (*Chrysanthemum Leucanthemum* and *C. segetum*) collected from barren hills and fertile valleys by LUDWIG and DE VRIES. But here at Clifton, Ohio, in the same spot, in the very same group of plants, undoubtedly consisting largely of the uniparental offspring of the very same individuals, the mean number of bracts was nearly 12.4 per cent. less in 1903 than in 1900, the mean number of rays was nearly 10 per cent. less, and the mean number of disk-florets 10.6 per cent. less.

If such differences as these are due to climatic fluctuations, it is of interest to consider what factors may have been important in producing them. As already mentioned, REINÖHL (1903) considers the chief factor in determining the number of parts in the androecium of *Alsine media* to be the condition of the available food-supply, whether this be dependent upon the character of the soil or upon photosynthetic activity conditioned by the intensity of the light. As the physical and chemical conditions of the soil in the Clifton ravine were doubtless essentially the same in the two years in question, the only soil factor which need be taken into account is water-supply as influenced by precipitation. REINÖHL (1903) states that he could

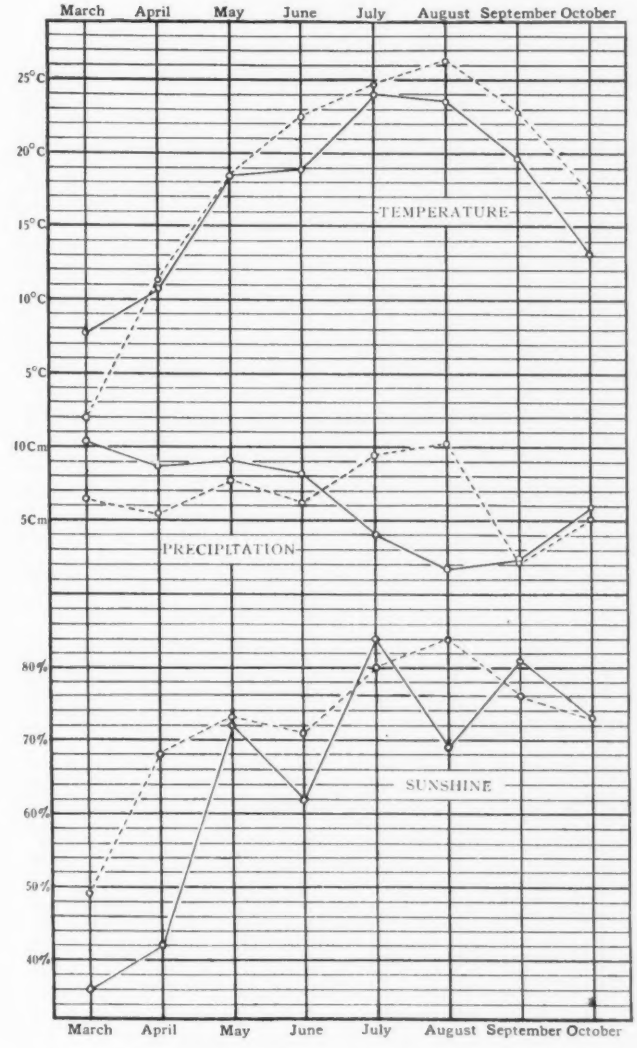



FIG. 18.—Comparison of the climatic conditions during the growing season of 1900 and 1903; dotted lines for 1900; unbroken lines for 1903; temperature curves represent conditions at Dayton, Ohio; precipitation curves are for Cedarville, Ohio; and the sunshine curves for Cincinnati, Ohio.

observe no influence produced by differences of temperature other than that of acceleration or retardation, but as conditions of nutrition are greatly affected by temperature, it is conceivable that it may be in some cases an important factor in determining variability. On these considerations I have sought to compare the season of 1903 with that of 1900 with respect to temperature, precipitation, and light. As the U. S. Weather Bureau records are not complete for any of these factors at Clifton, I have compared the conditions at the nearest stations at which complete records were available. In *fig. 18* these comparisons are represented graphically, the temperature-curves representing conditions at Dayton, Ohio, about 60 km distant, the precipitation-curves made from data for Cedarville, Ohio, 10 km distant, and the curves for light-intensity from the self-recording instrument at Cincinnati, Ohio, 160 km distant. These data are tabulated in Tables I, K, and L, along with the eleven-year or twelve-year normal, and such fragmentary data as were attainable for Clifton itself.

As this is the first attempt to refer changes in the variability of plants in a state of nature to definite climatic changes, there are obvious difficulties in the way of making satisfactory interpretations, and these difficulties can be overcome only by further study. We need to know (*a*) the relative importance of the several factors involved, (*b*) the harmonic optimum of each climatic factor for the species in question, (*c*) whether the critical period is that which precedes or that which accompanies differentiation, (*d*) the time of beginning and ending of the period of differentiation.

TABLE I.

TEMPERATURE IN DEGREES CENTIGRADE.

| | Dayton, O. | | | Clifton, O. | |
|---|---|---|---|---|---|
| | 1900 | 1903 | 11-yr. normal | 1900 | 1903 |
| March | 2.0 | 7.7 | 4.3 | .... | 8.9 |
| April | 11.3 | 10.7 | 11.3 | 10.3 | 10.6 |
| May | 18.4 | 18.4 | 17.4 | 18.0 | 17.9 |
| June | 22.4 | 18.9 | 22.6 | .... | 17.9 |
| July | 24.7 | 24.0 | 24.8 | 24.3 | 23.0 |
| August | 26.2 | 23.5 | 23.0 | 25.1 | 22.6 |
| September | 22.7 | 19.7 | 19.5 | .... | .... |
| October | 17.2 | 13.1 | 12.6 | .... | 13.1 |

TABLE K.

PRECIPITATION IN CENTIMETERS.

| | Cedarville, O. | | | Clifton, O. | |
|---|---|---|---|---|---|
| | 1900 | 1903 | 11-yr. normal | 1900 | 1903 |
| March | 6.45 | 10.41 | 10.14 | .... | 7.98 |
| April | 5.51 | 8.79 | 5.87 | 4.83 | 8.51 |
| May | 7.70 | 9.07 | 8.71 | 5.00 | 11.58 |
| June | 6.20 | 8.20 | 8.18 | .... | 11.94 |
| July | 9.32 | 4.11 | 9.63 | 13.05 | 3.05 |
| August | 10.29 | 1.75 | 5.54 | 9.04 | .79 |
| September | 2.08 | 2.46 | 5.74 | .... | .... |
| October | 5.11 | 5.92 | 4.67 | .... | 5.77 |

TABLE L.

LIGHT-INTENSITY AT CINCINNATI, OHIO.

| | 1900 | 1903 | 12-yr. normal |
|---|---|---|---|
| March | 40% | 36% | 45% |
| April | 68 | 42 | 56 |
| May | 73 | 72 | 62 |
| June | 71 | 62 | 72 |
| July | 80 | 84 | 76 |
| August | 84 | 69 | 75 |
| September | 76 | 81 | 72 |
| October | 73 | 73 | .. |

No study has been made to determine the period of differentiation in *Aster prenanthoides*, but I am assured by Dr. C. J. Chamberlain, who has studied *Aster Novae-Angliae*, that some of the heads in that species are already blocked out by the first of July. I consider it a fair assumption that the period of differentiation of the parts of the head in this species lies between June 1 and August 1.

If we accept the normal climatic conditions as near the harmonic optima (and this may not be a very erroneous assumption, since the area in question is near the center of range), we find that the conditions were more favorable in 1900 (*a*) with respect to June and July temperatures, the temperature for these months in 1903 being considerably below normal, (*b*) in July precipitation, 1903 having less than half the normal precipitation for that month, and (*c*) in light-intensity for every month, except possibly May, up to August 1, after which no factor could have any further influence. It may well be a question,

however, whether the harmonic optimum for light-intensity is not likely to be above the normal, the shade habit of *Aster prenanthoides*, as well as of other green shade plants, being assumed on account of the protection afforded against excessive transpiration, and not against excessive lighting. If this be true, the conditions in 1900 were even more favorable than here assumed, since with the exception of July the light-intensity was higher in 1900 than in 1903, being generally above normal in the former year, while in 1903 it was generally much below normal, being strikingly below in April and June.

These several advantages of 1900 over 1903 seem to be offset by the single factor of precipitation during May and June, the rainfall being appreciably below normal during those two months of 1900. As pointed out in the discussion of the habitat, it is probable that precipitation is of very slight importance in this case, leaving the low light-intensity and low temperature of the month of June, 1903, as probably the most important factors in bringing about the great change in the number of parts in the heads, the factors of next importance being possibly the very high light-intensity coupled with slight precipitation in the month of July 1903.

I wish to repeat that these conclusions are based on assumptions which need confirmation. It must not be forgotten that the after-effects of a preceding season or a rigorous winter may also be factors of importance, or even that there may be an internal periodicity which cannot be definitely referred to environmental fluctuations.

Two features of the frequency polygons for the bracts, rays, and disk-florets (*figs. 8–10*) are sufficiently striking to warrant consideration, their multimodality and their skewness. So much has been written upon the multimodal character of the frequency curves of phyllotactic organs that it need only be pointed out here that this additional collection of material shows no tendency to eliminate the multimodality observed in 1900, and though the errors of random sampling, which are very great in material of such wide range, must be held to account for most, if not all, of the irregularities of these curves (PEARSON 1902), there are some evidences that permanent modes may be developed on the Fibonacci series and LUDWIG'S "Unterzählen."

The constant recurrence of this series is not to be taken, however,

as has been maintained by LUDWIG (1899, 1901), as proof that variation in plants is fundamentally different from that in animals. When the phyllotactic series shall have been successfully analyzed, they may be found to result from the working out of more or less definite cell-lineages as supposed by LUDWIG (1888), or they may be the result of purely mechanical relations, as believed by SCHWENDENER, followed by WEISSE (1897) and CHURCH (1904), but either hypothesis, in explaining the occurrence of such series, must leave departures from the theoretical numbers to be accounted for as fluctuating variations. In addition to this variation about each number of the series, there is the general variation which may have a sufficiently wide range to allow the variates to coincide with two or more numbers of the phyllotactic series, so that we have in the case of phyllotactic variants two series of variations, the one overlying and partially masking the other. There can be little doubt that these variations taken separately will be found to agree with all the laws of variation determined for animals and the non-phyllotactic characters of plants.

Although DE VRIES (1899*b*) was able by selection to establish races of *Chrysanthemum segetum* having monomodal ray-curves, this must not be taken as supporting LUDWIG'S (1901) view that multimodality is due to the establishment of a mixed population of *petites espèces* through the common occurrence of asexual and autogamic sexual reproduction, for REINÖHL (1903) was able to reduce the multimodal curves of *Alsine media* to monodal curves *without selection*, by different degrees of light and manuring.

It is to be hoped that we shall soon have a method of treatment of phyllotactic variants which will remove the Fibonacci mask and permit the analysis of the underlying individual variation with as much precision as is now attained with non-phyllotactic variants.

Although it is impossible on account of the multimodality of these curves to analyze the skewness, it is so marked in the case of the bracts and rays (*figs. 8* and *9*) as to be recognized at a glance. There have been various interpretations of skewness in different connections, favorite early views (DAVENPORT 1901) being that it results either by the elimination of one or other of the extremes through the process of natural selection, or that heterogeneity is introduced by the

development of a new race within the range of the old but centering about a different mean. It is also believed that skewness may result from physiological causes having no direct bearing upon the origin or modification of species. While in no specific case may the suggested interpretation be the correct one, these different views may at least be accepted as evidence that skewness may result from various causes, and that it is therefore not self-explanatory.

If the 1903 curves are compared with those for 1900 in *figs. 11–13*, it will be seen that in every case the positive sides of the curves are approximately coincident, but on the negative side there is a very material disagreement. According to the recent discussion of skew variation by LUTZ (1904), we have here a case of skewness produced by the addition of variates, and this addition of such magnitude as already to overtop the 1900 population, thus giving a fine example of "historic" skewness; but no one can be convinced that this is here due to the "starting of a new race about a mean within the range of the old race."

It is evident that the skewness is here the result of direct physiological reaction to the changed environment. Not all individuals are alike sensitive to changed conditions, some being more, some less affected by a given amount of change; so that while many individuals respond to the less favorable conditions by the production of heads with smaller numbers of parts, there is still a considerable number of conservative individuals which are little or not at all affected. The positive skewness of these curves is due to the fact that only a small proportion of the population is conservative. If the great mass of variates had been comparatively conservative and only a small percentage sensitive to the changed conditions, it is plain that the position of the principal modes would have been little affected, while the mean would have been lowered and negative skewness would have been the result. This would then have been a case of so-called "prophetic" skewness. We may say then that in cases of direct or physiological variation, prophetic skewness indicates slight sensitiveness, and historic skewness great sensitiveness,[5] to the changed conditions, provided always, of course, that under ordinary conditions the distribution of the variates affected is normal.

[5] As measured by the number of sensitive individuals, not by the degree of sensitiveness of each individual.

Cases are well known in which the distribution does not appear to be normal under any ordinary conditions, the frequency curves being of the "half Galton" type, as for instance the petals of *Caltha palustris*, *Potentilla anserina*, *Ranunculus bulbosus* (DE VRIES 1894), *Ranunculus repens* (PLEDGE 1897), sepals and petals of *Ranunculus arvensis* (BURKILL 1902), leaflets of clover (DE VRIES 1899*a*), ascidia and other abnormalities of various species (DE VRIES 1899*a*, TAMMES 1903), and other characters. Such cases may not be really so exceptional, however, as they at first appear. We have only to assume that the normal condition for these characters is one in which the value of $\sigma$ approaches zero to see that these are cases of "prophetic" skewness due to the small proportion of abmodal variates; in other words, due to slight sensitiveness to conditions tending to produce a number of organs higher or lower than the normal mode.

It may be found that any population or even any species is sufficiently uniform in its reactions to various degrees of environmental change to allow us to derive from the direction and amount of skewness the approximate value of the mean under average conditions or under conditions which would give a normal distribution of the variates. Thus, the knowledge that this population of *Aster prenanthoides* is so sensitive to change as to exhibit strong positive skewness when conditions are below average may be found to warrant the assumption that there will be a strong negative skewness under unusually favorable conditions, and also that the skewness exhibited by a collection from any new locality would give an indication by its direction as to whether that collection was below or above the average prevailing condition for that place. But before we can apply this principle with any confidence in determining the "normal mean" of any particular population, it will be necessary to confirm our assumptions (*a*) that the distribution for that population is normal under average conditions, and (*b*) that the sensitiveness to unusually favorable conditions is similar in intensity to the sensitiveness to unfavorable conditions.

The principle here presented of variability in individual sensitiveness to changes of environment is likely to find a wide applicability in the interpretation of skew variation, and suggests the need of first determining whether or not there is direct variation of the organ or

character under consideration before assuming that either natural selection or mutation is involved in any given case of skewness. And although this is most strikingly true of plants, it must likewise be true of animals, especially of animals having a short life-cycle, so that no investigation can be considered as giving satisfactory support to any hypothesis of evolution until the sensitiveness of the character under consideration to secular changes shall have been determined.

Perhaps even more remarkable than the skewness and the changes in mean value, which have resulted from the less favorable conditions in 1903, is the great increase in value of the coefficient of variability. Reference to Tables E, F, and G will show that the variability in the bracts in 1900 was $12.979 \pm .241$, as compared with $19.928 \pm .345$ in 1903. Corresponding changes are shown in rays and disk-florets, from $14.516 \pm .270$ to $19.766 \pm .343$, and from $12.546 \pm .233$ to $21.595 \pm .374$, respectively. As it has been assumed that the low mean values indicate that conditions were less favorable in 1903 than in 1900, we may accept these changes in the coefficients of variability as proof of the hypothesis that when organisms are introduced into unusual surroundings or subjected to unusual conditions they become more variable, and that this would be favorable to any selective process which might set in as a result of the change. Before too great stress is laid on this conclusion, however, we need to consider the nature of the coefficient of variability. The importance of this constant lies in the fact that it is an abstract number and therefore allows us to compare the variability in characters of different magnitude or even of different quality, as color, form, size, weight, number, etc. It consists of two factors, the standard deviation ($\sigma$) and the mean ($M$), and is expressed by the formula $C.\ V. = \frac{100\sigma}{M}$. The value of the coefficient of variability will change directly with changes of $\sigma$ and inversely with changes of the mean. Turning now to the cause of the greatly increased coefficient of variability, we find upon inspecting Tables E, F, and G that the value of $\sigma$ was in every case considerably higher in 1903 than in 1900, and at the same time that the mean was much lower, so that both factors acted together in producing the high values of the coefficient of variability.

To show that this coefficient is not always a satisfactory measure

of variability, let us assume that conditions had been unusually favorable to such a degree as to give curves with the same values of $\sigma$, but negatively skew. The variability would then be approximately the same, but, instead of the coefficient being the same or even nearly the same, it would be very much less, owing to the greatly increased value of the mean. I do not think that $\frac{100\sigma}{M}$ gives a proper value of the coefficient of variability in cases of skew variation, since its values in positively skew curves are not comparable with those in curves of the same species or even of the same population, which are negatively skew. If the "normal mean" could be derived from skew curves, that might be used instead of the mean in the formula for the coefficient of variability, thus making the value of $\sigma$ alone indicate the changes of variability from time to time within one and the same population. This would be theoretically correct, but it must be evident that the experimental determination of the normal mean, except through a long series of investigations upon any population under consideration, is impossible, even though, as pointed out above, the degree and direction of skewness may in some cases give a rough approximation to it when the sensitiveness of the species in question is known.

Returning now to the question as to the increased variability due to changed environmental conditions, we find that the present imperfect coefficient of variability, which would tend to minimize the variability when conditions are unusually favorable, would still be considerably increased by such unusually favorable conditions as would result in a negative skewness equal in magnitude to the positive skewness of the 1903 curves. We may confidently accept the results of this study as proof, therefore, that changes of environment do result in increased variability.

It was noted in 1900 that the correlations between the parts in the head were very high, and by reference to Table H it will be seen that in 1903 they were very considerably higher still, the highest coefficient in both years being that between bracts and rays. The exact meaning of changes in the degree of organic correlation is proving a somewhat puzzling problem at the present time. LUDWIG (1901) presents a striking case of this kind as evidence of racial distinctness between

two populations of *Ranunculus ficaria*, but MACLEOD (1899) has shown that similar changes may be found in that species at different times in a single season. I have also found (SHULL 1902) that the coefficients of correlation in *Aster prenanthoides* may be very different at different parts of the season.

Before the significance of such changes can be understood it will be necessary to investigate the nature of correlation when considered in this statistical way. Some biologists use the term "correlation" to designate a relation between two organs or characters, such that the development of the one determines that of the other, as for instance the dependence of the secondary sexual characters upon the primary in animals, or the relation of the internodes to the leaves in plants. In this kind of correlation the failure of the one organ or character to develop, or its removal at an early stage of development, invariably prevents or modifies the development of the other. Every degree of correlation in this sense is found in different cases, and it probably exists to some extent even between organs whose immediate relations to each other are little understood. It is only rarely, however, that this kind of correlation is not insignificant as compared with biometrical correlation. Thus, in the biometrical sense there is a very high correlation between the index fingers of the right and left hands, but the removal of one of these would have no appreciable effect upon the development of the other.

For convenience we may speak of "immediate" or "direct" correlation when one organ or character stands in a direct causal relation to another, and "mediate" or "indirect" correlation in cases of correlated variation in which no such direct dependence exists. Statistical measures of correlation make no distinction between these two kinds of correlation, but as a notable degree of immediate correlation is comparatively rare, while mediate correlation is almost universal, the correlation of parts as spoken of by the biometrician may be considered as mediate or indirect. Mediate correlation between two organs or characters may be defined, then, as their mutual relation to the combination of common causes, such as heredity, nutrition, etc., which determine their quantitative relations. It is the relation which results in proportion and symmetry. When mediate correlation is perfect, *i. e.*, when $\rho = 1$, the two organs or

characters are proportionately influenced by every variation in the factors which determine their size, number, or other quantitative relation, and neither is affected by any factor which does not affect the other. The organs do not modify each other, but both are affected by the same conditions. Only confusion results from the failure to appreciate the difference between immediate and mediate correlation, as may be seen in BURKILL'S (1902) discussion of the correlation in the parts of the flower of *Ranunculus arvensis*, when he says that "reduction in the number of petals does not act as a reflex on the number of sepals in anything like the way in which the reduction of sepals may be said to promote reduction of petals."

If as the values of any pair of mediately correlated organs or characters are increased or decreased the correlation between them is changed, it must mean that one or other of them becomes proportionately less sensitive to the causes producing the change of values, and becomes more fixed or more variable in its quantitative relations. Such a change is well illustrated by an interesting diagram presented by BURKILL (1902), in which it is shown that sepals, petals, stamens, and carpels of *Ranunculus arvensis* vary together, *i. e.*, are closely correlated, in flowers having the total number of parts less than 19, but in flowers having a higher total number of parts the sepals become fixed in number at 5, and the correlation between sepals and the parts which continue to increase becomes zero. In flowers with more than 22 parts the mean number of petals likewise becomes fixed at 5. In flowers of still higher numbers of parts the carpels show a tendency to respond with proportionately less increase as compared with the stamens. It is plain then that in this species any conditions which promote the formation of flowers with a high number of parts will tend to decrease the degree of correlation and *vice versa*.

But it is an important fact which must not be overlooked that changes in the *coefficient* of correlation do not necessarily mean an actual change in correlation. PEARSON (1903) has pointed out that heterogeneity in a population tends to increase the coefficient of correlation, but of course such heterogeneity does not increase the actual degree of correlation. It is probable that most of the marked changes which have thus far been observed in coefficients of correla-

tion are to be accounted for in this way. I have already shown that my first collection in 1900 was made long after the beginning of the flowering season, and hence had the earliest heads with low numbers of parts associated with the heads having the highest numbers of parts produced during the season, and this fact sufficiently explains the high correlations found in that collection. A similar explanation may account for the considerable increase in the coefficients of correlation between the parts of the heads in 1903 as compared with those of 1900, as there are associated in the 1903 collection the heads of conservative individuals and those of individuals which were much modified because of their great sensitiveness to the unfavorable conditions in the latter year. It is apparent, therefore, that in cases of changed coefficients of correlation, as in other cases, it is necessary to scrutinize carefully the influence of more or less artificial conditions upon the value of the constants before we can appreciate their biological significance

The results of this study have fully borne out the suggestion that considerable differences may occur in individual variation from year to year, and it shows that such differences may be even greater than one would expect. It is not likely that this is an extreme case, nor that the differences between these two collections is even near the limit for this species. To some these results may seem to preclude the possibility of deriving anything of further value from quantitative studies of variation, while to others many new problems of great interest and importance will be suggested. The interpretations which students have based upon the assumption that seasonal fluctuations do not occur will have to be greatly revised or discarded altogether, and before we can appreciate the exact bearing of any case of variation upon the great problems of evolution it will be necessary to know the laws governing that variation. It is to problems of this nature that students must direct their earnest attention if we are ever to have a basis for the appreciation of the bearing of individual variation.

## VI. SUMMARY.

A second collection of heads of *Aster prenanthoides* Muhl. was made in 1903 from the same area at Clifton, Ohio, that supplied material for a quantitative study in 1900. The bracts, rays, and

disk-florets were studied quantitatively, and the results compared with those of the earlier study.

Twelve successive collections were made from the same plot, and it was found that the earliest collection had low mean numbers, that the mean values then leaped quickly to a maximum, falling gradually to near the end of the season, and that the last collection exhibited a rise, the rise in mean values at the beginning and at the end of the season being in disagreement with the conclusion reached in my earlier study. In general, the first head to bloom on any stem has the highest number of parts possessed by any head produced by that stem, and the last to bloom has the lowest number. The low mean numbers at the beginning of the season are due to the precocious flowering of the weakest individuals, and similarly the rise at the end of the season is due to the belated flowering of a few very vigorous individuals.

Comparison of the results with those of 1900 show that the mean values in 1903 were 10–12 per cent. lower than in 1900, and that accompanying these low mean values there are a strong positive skewing of the curves, a remarkable rise in the coefficient of variability, and a considerable increase in the coefficient of correlation.

The difference in the mean values for the two years is attributed to less favorable climatic conditions in 1903, chiefly to low temperature and low light-intensity in the month of June.

The skewness is due to the unequal sensitiveness of individuals to changes of environment. It is positive because the proportion of conservative individuals is small. In direct or physiological variation, "historic" skewness indicates great sensitiveness and "prophetic" skewness indicates slight sensitiveness to the changes of environment.

The great increase in the coefficient of variability is due to an increase in the standard deviation and a decrease of the mean. The present coefficient of variability is not satisfactory in cases of skew variation, and the value of $\sigma$ alone should be used as the measure of changes of variability in one and the same population.

Changes in the coefficient of correlation may be due either to an actual change of correlation or to the introduction of a greater or less degree of heterogeneity. The latter is probably responsible for the changes noted in this species.

I gratefully acknowledge my indebtedness to Dr. C. B. DAVENPORT, under the inspiration of whose lectures this study was undertaken, and under whose direction it was largely carried on; to Miss OLIVE D. COE for the care with which the material was collected, for the negatives from which *figs. 1, 4,* and *5* were reproduced, and for the original of *fig. 6;* to the Directors of the U. S. Weather Bureau stations at Columbus, Ohio, and at Cincinnati, Ohio, for climatological data; and to the curators of numerous public and private herbaria for the data upon which *fig. 3* is based.

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# BRIEFER ARTICLES.

## A NEW SHEEP-POISON FROM MEXICO.

THROUGH the kindness of Professor ALFRED DUGÈS of Guanajuato, Mexico, I have recently had an opportunity to examine specimens of a plant, locally known as *moradillo*, which occurs on the Hacienda de Santiago in Zacatecas, Mexico. This plant is said to poison sheep which eat it. From its floral structure, as well as its habit, there can be no doubt that it belongs to the small solanaceous genus Bouchetia. Only two species of this genus are recognized as valid, namely *B. erecta* DC. and *B. procumbens* DC., both published by DUNAL in De Candolle's *Prodromus* **13**[1]: 589. 1852. Of these, *B. erecta*[1] is a well-known much-branched erect or decumbent plant, 7 to 30 cm high, growing in rocky thickets, etc., of the southwestern United States, Mexico, and southward to Argentina. The corolla is 14 to 18 mm long, being about twice the length of the calyx. The proper tube of the corolla is short and entirely included within the calyx. The habit of the plant is closely that of an Evolvulus. *B. procumbens* is a very poorly known species, founded upon one of the drawings of the Mociño and Sesse collections. The tracing of this drawing (Calques des Dessins, *pl. 920*) shows a plant with a cluster of five slightly thickened roots. From the united summit of these spring eight leafy strongly decumbent or perhaps prostrate stems. These are in some cases as much as 12 cm long. The leaves have the narrow lanceolate or oblanceolate form prevalent in *B. erecta*, but the corolla has a slender considerably exserted proper tube. The limb is represented as about 1 cm broad, the lobes being subacute or even shortly acuminate.

So far as I know, the only specimen ever referred to this species since its description was a part of Schaffner's no. 611 from the Valley of San Luis Potosi, a plant so determined by Mr. W. B. HEMSLEY (Biol. Cent.-Am. Bot. **2**:437). This plant (in herb. Kew) I have not seen. Mr. HEMSLEY also mentions some specimens (Schaffner's no. 69 and Parry & Palmer's no. 701, from San Luis Potosi, as well as Graham's no. 270 from Jalapa)

[1] The synonymy of this species is as follows: *Nierembergia anomala* Miers, Ill. S. Am. Pl. **1**:99. *pl. 20*. 1846. *N. staticaefolia* Sendt. in Mart. Fl. Bras. **10**:179. 1846. *Bouchetia erecta* DC. acc. to Dunal in DC. Prodr. **13**[1]:589. 1852. *Leucanthea Roemeriana* Scheele, Linnaea **25**:258–259. 1852. *Bouchetia anomala* Britton & Rusby, Trans. N. Y. Acad. Sci. **7**:12. 1887.

which he doubtfully refers to a variety of *B. procumbens* with "floribus quam in icone fere duplo majoribus." Of the numbers here mentioned, Dr. Schaffner's no. 69 and Parry & Palmer's no. 701 are in the Gray Herbarium and appear identical with the sheep-poisoning plant recently sent by Professor DUGÈS. The stems are very short (3 to 4 cm in length) and prostrate; they spread from the summits of a 2–several-branched caudex. The flowers, mostly appearing terminal, are more than 3 cm long and 2 cm in diameter, the long slender proper tube of the corolla greatly exceeding the calyx. The lobes of the corolla are rounded or retuse. I cannot at all believe that this is the plant sketched in the Calques des Dessins, *pl. 920*, which has the grumose roots, far longer branches, narrower corolla-limb and pointed lobes. It seems best, therefore, to characterize the large-flowered plant as a new species. The name chosen alludes to its baneful effects on sheep.

**Bouchetia arniatera,** n. sp.—Perennis pilis albis minutis curvatis non-glanduliferis subcanescens: caudicis erectis vel patentis ramis subterraneis saepe elongatis flexuosis pallidis; caulibus aeriis pluribus brevibus 3–4 cm longis prostratis foliosis prope apicem florentibus: foliis lanceolatis vel elliptico-oblanceolatis 8–11 mm longis 2.5–4 mm latis breviter petiolatis acutis vel obtusiusculis uninerviis: pedunculis 3–6 mm longis teretibus; floribus solitariis: calycis lobis lanceolatis obtusiusculis erectis 4 mm longis quam tubus ovato-turbinatus paulo longioribus: corollae purpureae 32–35 mm longae 2 cm latae externe obscure glanduloso-puberulae tubo proprio gracili e calyce longe exserto, faucibus gradatim ampliatis, limbi lobis ovato-deltoideis apice rotundato vel retuso: filamentis equalibus paulo sub media parte corollae affixis filiformibus glabris 11 mm longis; antheris crassis ovoideis 1.5 mm longis: capsula ovoidea obtusiuscula 6 mm longa: seminibus 1 mm longis pallide brunneis irregulariter ovoideis, integumento externo sub laxe celluloso.—*B. procumbens*, var.? Hemsl. Biol. Cent.-Am. Bot. **2**:437. 1882.—In mountains of San Miguelita, Valley of San Luis Potosi, August, 1876, *Dr. J. G. Schaffner,*[2] no. 69 (hb. Gray), distributed as Petunia; San Luis Potosi, 1878, *Drs. Parry & Palmer*, no. 701

[2] The form of Schaffner's name here given is the one used on his printed Latin labels. Dr. Schaffner was a German apothecary, a native of Darmstadt, who settled in Mexico and collected extensively in the neighborhood of the city of Mexico, Orizaba, and San Luis Potosi. He signed himself in two ways, sometimes as Wilhelm Schaffner sometimes as J. G. Schaffner. The two signatures have given rise to some confusion and a question as to the identity of the person or persons concerned. The "G" doubtless stands for the Latin Guilielmus and the "J" probably for Johann or Johannes. This first initial, in the manner of the Germans being regarded as relatively unimportant, was dropped by Schaffner in his ordinary German signature.

(hb. Gray); Hacienda de Santiago, Zacatecas, communicated by *Prof. A. Dugès*, June, 1904 (hb. Gray).

The reported poisonous qualities of *B. arniatera* certainly raise a suspicion regarding the nearly related *B. erecta*, which is frequent in some grazing regions of our southwestern states where, in case of unexplained sheep-poisoning, it would be well for veterinarians to investigate the toxic effects of this plant.—B. L. ROBINSON, *Gray Herbarium*.

## SOME WESTERN SPECIES OF AGROPYRON.

**Agropyron spicatum Vaseyi** (Scribn. & Smith), n. comb.—*A. Vaseyi* Scribn. & Smith, U. S. Dept. Agr., Div. Agros., Bull. 4:27. 1897.

After a careful study of a large series of specimens I am disposed to regard *A. Vaseyi* as a depauperate form of *A. spicatum*.

**Agropyron subvillosum** (Hook.), n. comb.—*Triticum repens subvillosum* Hook. Fl. Bor.-Am. **2**:254. 1840. *A. dasystachyum subvillosum* (Hook.) Scribn. & Smith. U. S. Dept. Agr., Div. Agros., Bull. 4:33. 1897.

Much field study of this grass has led me to regard it as a distinct species. With its slender culms and small spikelets it is certainly quite different in appearance from the stouter and larger-flowered *A. dasystachyum* and *A. occidentale*. Often it is not at all glaucous, but quite green, and the flowering glumes are sometimes merely scabrous. It is very common in this region, occurring on bench-lands and alkali flats.

**Agropyron Bakeri,** n. sp.—A smooth cespitose perennial, with stout culms, 3–5 dm high: leaves rigid, flat, prominently striate-nerved; culm leaves three, 12–20 cm long, 2–4 mm wide, those of the innovations longer: spike 9–12 cm long, scarcely exserted, equaled or exceeded by the uppermost leaf; spikelets terete, 5–9 mm distant, 5-flowered, 15–19 mm long: empty glumes 11–12 mm long, two-thirds the length of the spikelets, 5-nerved (the nerves scabrous), margins scarious, narrowly oblong, somewhat abruptly narrowed into an awn 2–8 mm long, and with or without a tooth to one side at the base of the awn: flowering glumes scabrous or nearly smooth on the back, the strong midnerve extended into a rigid widely spreading awn 10–35 mm long, often bidentate below the origin of the awn: palea equaling or somewhat exceeding its glume: rachilla scabrous.

Related to *A. violaceum* and *A. Gmelini*, but distinguished by its stout culms, firm and strongly nerved leaves, and long widely spreading awns. Type specimen in the Rocky Mountain Herbarium, collected by C. F. BAKER, no. 139, near Pagosa Peak in southern Colorado, altitude 2750 m (9000 feet), August, 1899.—ELIAS NELSON, *University of Wyoming, Laramie*.

## NOTE ON SOME BRITISH COLUMBIAN DWARF TREES.

(WITH THREE FIGURES)

WHILE at the Minnesota Seaside Station on the west coast of Vancouver Island during the past summer, an interesting forest of dwarf trees was discovered. For the most part they grew on the weather-worn edges of a strongly inclined slate formation, but a few were found in crevices between blocks of diabase. They were all close to the sea, but outside the influence of the surf. Mr. F. K. BUTTERS and I succeeded in getting a number of

FIG. 1.

photographs, after securing which we cut down the trees and determined their age by the help of hand lenses and the compound microscope.

The dwarf trees were of three species: *Picea sitchensis*, *Tsuga heterophylla*, and *Thuja gigantea*. The pictures herewith presented, however, are all of the Sitka spruce. *Fig. 1* shows the largest tree photographed and also the youngest. It was a little less than two feet high and sixty-eight years of age. The leaf-bearing phytomeres were decidedly short, but the leaves remain upon the twigs for several years, so that the effect in the picture is of twigs of ordinary length. *Fig. 2* shows a tree growing in a

cleft of the diabase. It was less than a foot in height, with trunk three-quarters of an inch in diameter. It turned out to be eighty-six years old. *Fig. 3* shows a tree cut down and held in the writer's hand. It was about a foot high, with trunk one inch in diameter, and ninety-eight years old.

These trees have very much the appearance of the well-known Japanese dwarf trees, so much so indeed that it would be an easy matter for the unscrupulous to pot them and palm them off on innocent purchasers. Their striking resemblance to the famous products of Japanese horticultural art suggested to me that from such seashore dwarfs the Japanese might very easily have obtained their hint and learned the tricks of culture.

FIG. 2.

Two strong dwarfing influences are at work upon these little British Columbian trees. In the first place, the root system is strongly compressed between plates of rock. Of some of these trees the whole root system was exposed and it looked a good deal like a sheet of brown paper with the trunk of the tree attached to one edge. In the second place, the winds from the sea dwarf and contort the twigs. So with great pressure upon the root system and strong wind action upon the shoot the dwarfing is accomplished.

These little trees have a very different appearance from the slender dwarf spruces of bogs in northern Minnesota. In such regions trees with trunks an inch or so in diameter have been noted, showing an age up to sixty years, but they are tall, slender, and regular in the arrangement

of their branches. The dwarf trees of mountain tops have likewise a decidedly different appearance, so far as they have come within my observation, and do not particularly resemble the Japanese products.

I do not remember to have seen it suggested anywhere that the dwarf

FIG. 3.

trees of Japan are essentially of seashore origin, but in view of the little natural forest on the coast of Vancouver, I think it very possible that this is a correct explanation.—CONWAY MACMILLAN, *University of Minnesota, Minneapolis.*

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## CELLOIDIN TECHNIQUE: A REPLY.

IN THE August number of the GAZETTE, Dr. CHARLES J. CHAMBERLAIN publishes a criticism of a recent contribution by Mr. A. B. PLOWMAN on the subject of celloidin imbedding. As the account of the method was written up by Mr. PLOWMAN at my suggestion, and the "Correction" of Dr. CHAMBERLAIN contains several misconceptions, I think it well to publish a short reply. Dr. CHAMBERLAIN is unable to find anything new in the method beyond the preliminary use of hydrofluoric acid. If so accomplished a technician takes the trouble to reperuse the article in question,

he will discover, in the very careful removal of air from the tissues before imbedding, the numerous accurately graded solutions of celloidin (2, 4, 6, 8, etc., per cent.), the repeated heating and rapid cooling of the objects during the process of infiltration, the thickening of the final matrix by the addition of chips of celloidin and the use of heat (instead of the usual process of evaporation), the hardening by means of chloroform followed by STRASBURGER'S solution of equal parts of alcohol and glycerin, the method of attaching the objects to the microtome, etc., etc., features of greater or less novelty in celloidin technique. It is scarcely necessary to discuss the misconception on the part of Dr. CHAMBERLAIN, by which he supposes Mr. PLOWMAN to claim originality in the matter of using celloidin as an imbedding medium. The reference to previous incomplete accounts was perhaps unfortunate, but was due to the fact that Mr. C. H. MILLER, an assistant in the Anatomical Department of the University of Chicago had described imperfectly the celloidin method at present under discussion as derived from Prof. R. R. BENSLEY, a former colleague of the present writer. In his chapter on celloidin technique, Dr. CHAMBERLAIN too makes reference to his indebtedness to Mr. W. B. MAC CALLUM, a former student of the Ontario Agricultural College, an institution into which the present writer's celloidin method had certainly been introduced. The writer is glad to accept Dr. CHAMBERLAIN'S statement, in a letter to Mr. PLOWMAN, that he owes nothing to Dr. MAC CALLUM. The mention of possible prior publication arising out of the wide informal diffusion of the method was not introduced out of any desire to establish priority, but for the purpose of obviating just such well meant criticisms as that of Dr. CHAMBERLAIN. The excuse for publishing the method is the fact that it gives results which excel those obtained by any other process known to the writer.—E. C. JEFFREY, *Phanerogamic Laboratories of Harvard University.*

THE correction to which Professor JEFFREY refers in his reply was based upon the following data:

Celloidin in 2, 4, 6, 8, 10, and 12 per cent. solution is mentioned in LEE'S *Vade Mecum* (ed. 3, 1893, pp. 193–195). The series in multiples of two seems due to the fact that the SCHERING'S celloidin, which is most commonly used, comes in tablets accompanied by directions stating that a 2 per cent. solution may be made by adding to a tablet a sufficient quantity of ether-alcohol to make the whole weigh 2000$^{gm}$. For a 4 per cent. solution another tablet could be added, and so on. The chloroform method for hardening celloidin after infiltration was described by VIALLANES in 1883 (Rech. sur l'hist. et le dével. des insects, p. 129; also Revue scientifique **31**: 684–687.

1883). A mixture of equal parts of glycerin and alcohol was recommended by STRASBURGER (Das botanische Practicum 1884, p. 79) for facilitating the cutting of woody tissues. EYCLESHYMER (Amer. Naturalist **34**: 354–357. 1892, and Jour. Roy. Micr. Soc. **1892**: 563–565) describes a series of four grades of celloidin for infiltrating, chloroform for hardening, and a treatment with glycerin before cutting. In view of these facts, we do not doubt that others, who like ourselves have used STRASBURGER'S method for softening woody tissues, have continued to use the glycerin and alcohol mixture when dealing with material imbedded in celloidin.

Mr. PLOWMAN has certainly presented the subject in a very usable form, and in perfecting the application of fluoric acid he has made it possible to obtain better sections of refractory tissues. In my "correction" I intended merely to lodge an objection to the characterization of my account as a second-hand presentation of Dr. JEFFREY'S methods. A study of LEE'S *Vade Mecum* and the references there cited indicates that Dr. JEFFREY, like myself, is deeply indebted to previous investigators.—CHARLES J. CHAMBERLAIN.

I HAVE been permitted to read the proof of Dr. CHAMBERLAIN'S comment on my letter. Matters have now resolved themselves into a difference of opinion between Dr. CHAMBERLAIN and myself as to what constitutes novelty and improvement in celloidin technique. I am very willing to allow the case to rest on the practical value of the method published by Mr. PLOWMAN.—E. C. JEFFREY.

## AN ABNORMAL AMBROSIA.

(WITH THREE FIGURES)

A PLANT of *Ambrosia artemisiaefolia* that had been run over by a wagon and badly injured bore both staminate and pistillate flowers in an abnormal condition. The young shoots bearing the flowers arose vertically from the prostrate and injured main stem.

The staminate flowers of this injured plant appeared larger than the normal. The heads were scattered, forming a loose raceme, and each contained fewer flowers than usual. In the center of the older flower heads there was a group of buds that appeared to be vegetative (*fig. 1*), while the younger heads contained vegetative buds only within the bracts enclosing the heads, the flowers having been entirely replaced. Instead of the sterile style the older staminate flowers bore vegetative buds in the center (*fig. 2*). The pollen of these flowers appears to have been arrested

in development. In some cases the grains were shriveled and not well formed, in other cases the pollen seemed to have been checked just beyond the tetrad stage.

The pistillate flowers of the same plant bore no ovules, but instead of them there were small vegetative buds (*fig. 3*). These flowers were not clustered as usual, but were mostly in the axils of leaf-like bracts, for the most part being considerably separated and forming a very loose raceme. The styles were glandular at tip only. In tracing the development, the bud appeared very early replacing the ovule, and the parts of the flower were more lengthened. A rudimentary ring-like outgrowth appeared just beneath the carpel, corresponding to the corolla of the staminate flower (*fig. 3, p*).

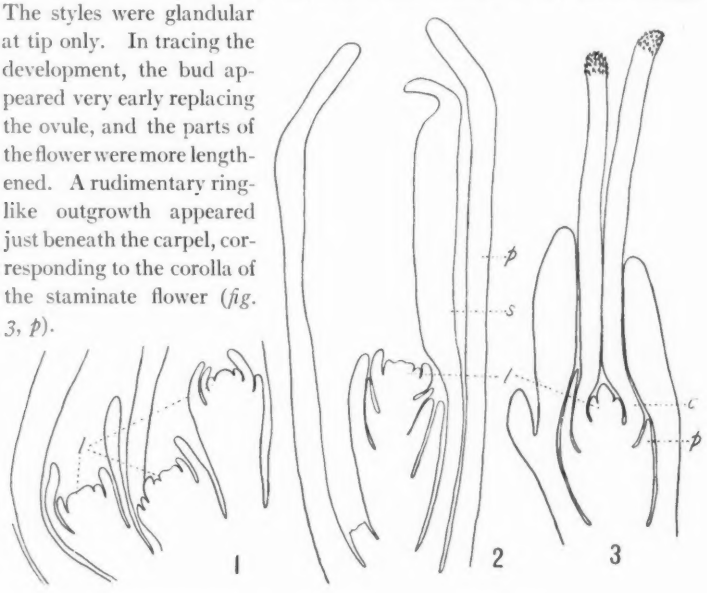


FIG. 1.—Vegetative buds (*l*) in the center of a staminate head.
FIG. 2.—A vegetative bud (*l*) replacing the sterile style; *s*, stamen; *p*, corolla.
FIG. 3.—A vegetative bud (*l*) replacing the ovule; *c*, carpel; *p*, corolla.

All the staminate flowers examined had styles more or less rudimentary. In some of the marginal flowers the styles protruded beyond the corolla and were terminated by a disk fringed by glandular hairs. Ovules were not formed in any specimen, but a tissue that had the appearance of a rudimentary ovule was seen in some flowers.

It would appear that under the abnormal conditions described the primordia that usually form reproductive parts produced vegetative parts. —A. C. LIFE, *Shaw School of Botany, St. Louis, Mo.*

# CURRENT LITERATURE.

## BOOK REVIEWS.

### The adaptation theory.

FROM THE time of LAMARCK the theory of direct adaptation to environment has found its adherents, and there certainly appear to be many facts which are best explained by some such theory. Dr. CARL DETTO, assistant at the Botanical Institute of the University of Jena, has made a careful reinvestigation of the subject, in the light of the most modern botanical knowledge.[1] The first chapters deal with methodological postulates and a general statement of the problem of adaptation. It is evident from the first sentences that the author is radically opposed to the Lamarckian theories and especially to the Neolamarckian aspect of those theories as held, for example, by Wettstein. It is to be feared that DETTO sometimes loses the appearance of impartiality, and becomes a partisan, anxious to maintain his view at all hazards. He regards the capacity for an advantageous response to new and hitherto unexperienced conditions as the central feature of Lamarckism, and thinks that the most refined Neolamarckian views are of a kind with the more coarse and obviously teleological expressions of LAMARCK and NÄGELI. He believes that those who hold to direct adaptation are necessarily teleologists and vitalists, and fundamentally in error because they attempt to explain physical phenomena by means of psychological data. The presence within an organism of a capacity for an advantageous response to changed conditions is called an ecologism, while the development of an advantageous from an indifferent state is called ecogenesis. The difficulty with Lamarckism is that it takes the ecologism for granted; a true explanatory theory will have to explain how it came into existence, *i. e.*, we are in need of a theory to account for ecogenesis.

DETTO examines the evidence that has been adduced in support of direct adaptation, especial consideration being given to "accommodation" or "regulation," as exhibited by bacteria, molds, the biological species among the Uredineae, and the "xerophytic," "hygrophytic," and "hydrophytic adaptations" among vascular plants. Many changes usually regarded as advantageous, which ensue when aerial organs are placed in water, are here referred to hypoplasy, and it is held that the reduced or modified structures may be of slight benefit or even no benefit at all. Other changes may be due to reversion, or to the removal of the cause of arrest. The chief recourse of the author, however, is to what he terms the

[1] DETTO, CARL, Die Theorie der direkten Anpassung und ihre Bedeutung für das Anpassungs- und Deszendenzproblem. Versuch einer methodologischen Kritik des Erklärungprinzipes und der botanischen Tatsachen des Lamarckismus. 8vo. pp. vi + 214. Jena: Gustav Fischer. 1904. *M*4.

potential limit of variation; the supposed direct adaptation is in reality nothing new, but rather the manifestation or release of a hitherto latent property. The new habitat is merely empirically new. Consequently DETTO agrees with KLEBS that a species should not be defined as it exists normally in nature, but should include all possible variations in all imaginable conditions. The capacity of an organism is not widened but demonstrated by environmental changes. Direct adaptation or ecogenesis is impossible because it implies that there is a setting aside of the constitutionally prescribed effect of a given stimulus in the interest of the organism, or that menacing factors are in reality beneficial. The direct adaptationist conceives of a vital mechanism that looks out for the future, and holds advantageous reactions in readiness for conditions which have never yet occurred! Ecogenesis must therefore be indirect in all cases, chance alone determining whether the new ecologism is of advantage or not. DETTO, who agrees with KLEBS at so many points, holds in direct opposition to him that the external world causes no changes whatever in plants; every plant character is an organization character (in Nägeli's sense) and the external conditions in which a plant is placed act merely as releasing stimuli.

The book should be read carefully by all who are interested in the philosophy of adaptation, since the volume as a whole is so written as to stimulate good thinking. However, it seems to the reviewer that the perspective is frequently distorted. In this country, at least, there is no need for such a continuous and hearty lampooning of teleological and vitalistic views, for they have been long since abandoned by most scientific investigators. That chance determines success and not a prudent foresight on the part of the plant is certainly the common view. Again, if one holds to a *potentielle Variationsbreite* wide enough to embrace all changes that ever occur in plants, it is obviously impossible ever to demonstrate the contrary by experiment; it is a concept incapable of proof or disproof. It seems far better to hold that both the organism and the environment are needed to secure the evolution of new forms; any other view seems to the reviewer fundamentally unthinkable.—HENRY C. COWLES.

### Matthias Jacob Schleiden.

AN APPRECIATIVE biography of SCHLEIDEN by M. MÖBIUS, was published on the centennial of his birth, April 5, 1904.[2] MÖBIUS was related by marriage to SCHLEIDEN (whose second wife was MÖBIUS'S maternal aunt), and to him family sources of information have been open. SCHLEIDEN'S life was uneventful save for two incidents; the one an attempt at suicide on account of his want of success and dissatisfaction in the legal profession, and the second his resignation of the professorate at Jena because of the refutation of his theories on the origin of cells and the formation of the embryo. Clear and vigorous in thinking and expression, he demanded accuracy and lucidity in others and was ever ready to

[2] MÖBIUS, M., Matthias Jacob Schleiden zu seinem 100 Geburtstage. 8vo. pp. iv + 106, portrait, *figs. 2*. Leipzig: Wilhelm Engelmann. 1904. *M* 2.50.

criticise sharply. Indeed, polemics seem to have been his delight, and he attacked without reference to the standing of his antagonist, as his famous controversy with LIEBIG shows, *à propos* of which UNGER wrote ENDLICHER: "Den arroganten Liebig hat Schleiden ganz köstlich zugedeckt."

The greater part of the book is devoted to an account of SCHLEIDEN'S published work, including an account of his famous cell-theory, his classical *Grundzüge der wissenschaftlichen Botanik*, many minor papers, popular addresses and books, his editorial activity, and his philosophical, religious, and speculative writings. For many important services to the science of his day, and especially to botany, this many-sided man deserves of the present generation fuller recognition. This book, with its interesting portrait and character portrayal, will promote this and is a useful contribution to the history of botany.—C. R. B.

## MINOR NOTICES.

ENGLER [3] has published a new edition of his *Syllabus*, including the most recent results of his views as to relationships. This complete outline of his classification, including as it does the whole plant kingdom, is of great service to students of morphology as well as of taxonomy. There is a prefatory statement of the principles of this particular scheme of classification, and an appendix containing the geographical regions recognized by the author.—J. M. C.

WILLOUGHBY, Vermont, has long been famous for its flora, and KENNEDY [4] has done good service in publishing a compact account of the region and a list of 690 plants. The characteristic features of the region are wet cliffs and slides and sphagnous cedar swamps. The small area in which the species are massed is remarkable, probably nine-tenths of the indigenous species being found in two square miles.—J. M. C.

COULTER and DORNER [5] have published a simple key to the genera of the forest trees of Indiana, using the most obvious characters. Its practical value in large classes has led to its publication, and its usefulness is not restricted to Indiana.—J. M. C.

CRATTY [6] has published a list of the vascular plants growing in Emmet county, Iowa, a northwestern county bordering on Minnesota. The list includes 590 numbers.—J. M. C.

[3] ENGLER, A., Syllabus der Pflanzenfamilien. Eine Uebersicht über das gesamte Pflanzensystem, etc. Vierte, umgearbeitete Auflage. 8vo. pp. xxx+237. Berlin: Gebrüder Borntraeger. 1904. *M*4.

[4] KENNEDY, GEORGE G., Flora of Willoughby, Vermont. Reprinted from Rhodora **6**: 93–134. *pls. 54–56*. 1904.

[5] COULTER, STANLEY, and DORNER, H. B., A key to the genera of the forest trees of Indiana, based chiefly upon leaf characters. 16mo. pp. 12. Lafayette, Indiana: published by the authors. 1904.

[6] CRATTY, R. I., Flora of Emmet county, Iowa. A list of the native and introduced plants. Reprinted from Proc. Iowa Acad. Sci. **11**: 201–251. 1904.

## NOTES FOR STUDENTS.

YABE [7] gives his opinion that COVILLE'S ericaceous genus Arcterica,[8] from Bering Island, is *Pieris nana* Makino, common on the higher peaks in Honshu and Hokkaido, Japan. The plant was originally described as *Andromeda nana* Maxim., of which genus Pieris is often regarded as a section.—J. M. C.

HOLM [9] has been investigating the inflorescence of Cyperus, chiefly with reference to the prophylla. It is claimed that by means of the "cladoprophyllon" the originally erect and congested rays of the umbel are brought to their more or less horizontal position. Also, the small bodies always observable at the base of the secondary branches of the inflorescence of grasses, more distinct in large panicles, are said to represent rudimentary prophylla identical with those characteristic of the Cyperaceae.—J. M. C.

FUJII [10] in a short preliminary announcement gives the results of his investigations upon the droplet which exudes from the micropyle of gymnosperms at the time of pollination. The preliminary announcement deals with *Taxus baccata*. Chemical tests indicate that the droplet contains glucose and calcium. A kind of gum and perhaps also malic acid are present. SCHUMANN claimed that only one droplet is produced. The present investigation shows that droplets may be formed repeatedly, both in the laboratory and in the field.—CHARLES J. CHAMBERLAIN.

VERSCHAFFELT [11] finds that the minimum lethal strength of some toxic solutions for fleshy or succulent organs of potato, Aloe, Rheum, etc. can be determined with fair accuracy by noting the change in weight which occurs when the test object is removed from the toxic solution and immersed in water. The basis of the method is that tissues which have succumbed to toxic exposure lose in weight by yielding osmotically held water, or at least do not gain in weight by water absorption as compared with controls. The method has limitations, some of which are noted by the author.—RAYMOND H. POND.

THE EXPERIMENTS upon which Elfving based his theory of positive and negative galvanotropism have been repeated by PLOWMAN [12] with results for the most part confirmatory. Two exceptions to be noted are, first, that an electric

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[7] YABE, Y., On a new genus Arcterica. Bot. Mag. Tokyo **18**: 127–128. 1904. Abstract.

[8] See BOT. GAZ. **37**: 298–302. 1904.

[9] HOLM, THEO., Studies in the Cyperaceae. XXIII. The inflorescence of Cyperus in North America. Am. Jour. Sci. IV. **18**: 301–307. 1904.

[10] FUJII, K., Ueber die Bestäubungstropfen der Gymnospermen. Vorläufige Mitteilung. Ber. Deutsch. Bot. Gesells. **21**: 211–217. 1903.

[11] VERSCHAFFELT, E., Determination of the action of poisons on plants. Konin. Akad. Wetens. Amsterdam **1904**: 703–707.

[12] PLOWMAN, A. B., Electrotropism of roots. Amer. Journ. Sci. IV. **18**: 228–236. *pls. 9–10.* 1904.

current passing through water in which seedlings are growing is not necessarily fatal, and that the roots of such seedlings will curve toward the positive pole even when the current is of less than lethal strength; second, that negative galvanotropism is not a constant property of any species thus far studied. Since electrons instead of ions are the cause of the curve responses the author proposes to substitute for Elfving's "galvanotropism" the term "electrotropism."—RAYMOND H. POND.

NEWCOMBE [13] reports experiments on thigmotropism of terrestrial roots which show very feeble sensitiveness of the terminal millimeter and of the growing region, the few responses being positive and the angle of deviation small. Many ingenious modes of securing continuous pressure and avoiding hydrotropic stimuli as far as possible were tried. The most convincing results were gained by surrounding roots with collapsible collodion tubes, and using a water stream to give the pressure. The tubes do not allow appreciable filtration. These experiments gave strong evidence for the identity of rheotropism and thigmotropism, and NEWCOMBE applies to thigmotropism the results given by his earlier experiments on rheotropism.[14] The sensitiveness is equal on all sides, and the stimulation must extend over a considerable area and be continued for some time to produce a complete reaction. The feeble sensitiveness is probably of no utility to the plant.—C. R. B.

BRANDT holds [15] that REINKE errs in thinking the N-content of the sea small [16] because little is added to it. His estimates of the yearly addition of organic N-compounds and of inorganic N-compounds by rains would indicate an N-content in sea water that analysis does not corroborate. This discrepancy is explained by the active dentrification through the action of bacteria, so that the N-content never surpasses a minute amount. This dentrification has been shown to occur and the bacteria have been carefully studied in several localities in the North Sea, the East Sea, and even in the Antarctic under the ice. It is the chief reason for the smaller N-content of tropical waters and this difference determines the lesser amount of plant life there. BRANDT believes the N-supply quite adequate without special appeal to such bacterial symbionts as Clostridium and Azotobacter, though these insofar as they occur may be effective. For example, in the water of Kiel Bay (at 20m) the content in inorganic N is four times that of the plankton.—C. R. B.

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[13] NEWCOMBE, F. C., Thigmotropism of terrestrial roots. Beihefte Bot. Cent. **17**: 61–84. 1904.

[14] BOT. GAZ. **33**: 183. 1902.

[15] BRANDT, K., Ueber die Bedeutung der Stickstoffverbindungen für die Production im Meere. Beihefte Bot. Cent. **16**: 383–402. 1904.

[16] REINKE, J., Die zur Ernährung der Meeres-Organismen disponiblen Quellen an Stickstoff. Ber. Deutsch. Bot. Gesells. **21**: 371–380. 1903. See BOT. GAZ. **37**: 228. 1904.

PILOSTYLES is a genus of the Rafflesiaceae parasitic upon various Leguminosae. Material from Brazil has been studied by ENDRISS [17] in GOEBEL'S laboratory. The staminate flower consists of a solid axis in which are imbedded two circles of sporangia, with 18–20 sporangia in each circle, twenty being probably the usual number. If four sporangia represent one anther, the whole structure would represent five anthers, corresponding in some measure to the relations obtaining in the ovulate flower, which has normally five placentae. While the flowers are monosporangiate, a rudiment of the ovary appears as a column in the center of the staminate flower. In related forms the flowers are said to arise endogenously, within an originally compact tissue. In *Pilostyles Ingae* the flowers are strictly exogenous. The pollen grains are extremely small, measuring only 5 $\mu$ in diameter. Some flowers have been pollinated, but in only one case had pollen tubes begun to form. Many older seeds contained embryos, but no trace of pollen or pollen tubes could be found. The writer doubts whether normal fertilization occurs. The anatomy of the plant and the development of the embryo are described.—CHARLES J. CHAMBERLAIN.

VARIOUS ATTEMPTS have been made to attribute to external conditions the polarity seen in cuttings of roots and shoots. The latest effort is by KÜSTER, who discusses in a preliminary paper[18] the influence of oxygen and of centrifugal force upon polarity, and in a second [19] enlarges upon the same topic. KÜSTER placed the roots of Taraxacum, which under uniform conditions of moisture produce roots at the apical (normally lower) end and shoots at the basal end, with their basal (normally upper) ends in water and the opposite ends pointing upwards into the air. Shoots develop on the latter end and none on the parts in water. Cuttings of the stems of *Ribes aureum* placed with their basal ends in water and their apical ends in moist air produced roots only on their apical ends. *Salix vitellina* gave similar results, showing a marked tendency for the roots to appear only where there is a sufficient supply of air. Cuttings of Salix and other plants were rotated horizontally on a centrifuge. The centrifugal force acted as a check upon development, the inhibition being in proportion to the force, *i. e.*, if the apical end describe the greater circle the buds there are inhibited more than those at the opposite end. In this way the usual polarity may be reversed.—W. B. MACCALLUM.

LYON[20] has made a detailed and much-needed study of the embryogeny of Ginkgo, with an unusual abundance of illustration. The general undifferentiated mass of tissue that is known to fill the egg after free nuclear division is called

[17] ENDRISS, W., Monographie von *Pilostyles Ingae* (Karst.). (*Pilostyles Ulei* Solms-Laub.) Flora **91**: 209–236. *pl. 20. figs. 31.* 1902.

[18] KÜSTER, ERNST, Experimental Untersuchungen über Wurzel- und Sprossbildung an Stecklingen. Ber. Deutsch. Bot. Gesells. **22**: 167–170. *pl. 1.* 1904.

[19] KÜSTER, Beiträge zur Kenntnis der Wurzel und Sprossbildung an Steckling. Jahrb. Wiss. Bot. **40**: 279–302. *figs. 4.* 1904.

[20] LYON, HAROLD L., The embryogeny of Ginkgo. Minn. Bot. Studies **3**: 275–290. *pls. 29–43.* 1904.

the "protocorm." The cells in the micropylar two-thirds of this spherical protocorm divide little or not at all, but the cells of the antipodal extremity form a small-celled meristem which passes over directly into the meristem of the "blastema" or "metacormal bud." The blastema invades the endosperm as a broad, blunt cylinder, the protocormal tissue being forced back through the neck of the archegonium, many of its cells often being crushed. The metacormal bud is meristematic throughout, but soon two "growth-foci," those of stem and root, are organized in its axis and very close together. Later the primordia of the two cotyledons are organized in the marginal region of the broad apical meristem. Thus in the organization of the embryo much of the original protocormal tissue is not involved, heretofore being described as a rudimentary suspensor. There are usually two cotyledons, but in certain of the material three cotyledons were quite common; they are normally equal and entire, and spring apart when liberated from the seed. The anatomy of the embryo, including its histogenesis, is also described.—J. M. C.

BESSEY has studied the effect of various external factors on the pigment formation in several fusarium-like fungi.[21] The plants used were (1) two fungi, closely resembling each other, isolated from the roots of diseased sesamum plants, (2) *Neocosmospora vasinfecta* and (3) its variety *nivea*, and (4) *Fusarium culmorum*. Of these the first four when grown on acid media produce a red pigment which changes to dark blue when treated with alkalies. The fungi were grown in KNOP's solution to which the substances to be tested were added. No general relation could be established between the composition of the culture medium and the production of pigment. Mono-, di-, tri-, and polysaccharides generally gave a red or violet pigment, which changed to blue in cases where the culture became alkaline during the experiment (gelose). Organic acids gave a scarlet color, except palmitic acid which is not soluble. Salts of the acids with few exceptions gave no pigment. In alkaline media no pigment production takes place. Absence of air also suppresses the development of the coloring matter. These fungi also produce a yellow pigment whose formation is independent of the character of the substratum. Light and oxygen are necessary for its production. The pigments are formed in the cells of the fungi and not primarily in the substratum as has been stated.—H. HASSELBRING.

SHIBATA'S [22] mycological studies of endotrophic mycorhizas in Podocarpus, Psilotum, Alnus, and Myrica have given the following results: In the tubercles of Podocarpus the mycelium of the fungus develops extensively, and is then digested and resorbed by the cells of the host. The nucleus of the infected cell divides repeatedly amitotically, the nuclei increasing greatly in staining capacity

[21] BESSEY, Ernst A., Ueber die Bedingungen der Farbbildung bei Fusarium. Flora **93**: 301–334. 1904.

[22] SHIBATA, K., Cytologische Studien über die endotrophen Mykorrhizen. Jahrb. Wiss. Bot. **37**:643–684. *pls. 14–15*. 1902.

on account of the increase in a nuclein-like material. After the digestion of the fungus the nuclei of the host cells resume their normal appearance. The increase and subsequent decrease in the nuclein-like material indicates that the nucleus takes part in the formation of enzymes. The amitotic division is not an indication of degeneration, but is rather a means of increasing more rapidly the nuclear material. After the fungus has been digested, mitotic division is often seen in the multinucleate cells, showing that nuclei after dividing amitotically may again divide by mitosis. The number and arrangement of the chromosomes does not seem to be affected by the previous amitotic division. In Psilotum the cells containing the fungus can be distinguished as host cells and digesting cells. The nuclear change consists chiefly in a great increase in the chromatin. The formation of transverse walls in the intracellular hyphae is almost entirely suppressed. In Alnus the fungus is not a true hyphomycete. A plasmatic body appears in the nucleus of the infected cell, and within the body are numerous droplets which disappear after digestion of the fungus has been completed. The fungus in Myrica belongs to the genus Actinomyces, the first instance of actinomycosis recorded.

In all the mycorhizas studied the cytological changes are intimately connected with the intracellular digestion of the fungus substance. The presence of a typical digestive fluid was established in all cases. The mode of nutrition of the endotrophic fungus is still an open question.—CHARLES J. CHAMBERLAIN.

AMAR [23] has recorded data obtained from histological and physiological study of the rôle of calcium oxalate in plant nutrition. As a general rule the root contains few if any crystals, and they become less numerous as one follows the course of foods from the leaf blade to the root. Crystal formation in the leaf is localized chiefly in tissues adjacent to those concerned with photosynthesis and conduction. The crystals represent excreted waste and not reserve products in storage. AMAR seeks to relate the formation of oxalate crystals to physiological conditions resulting from the chemical composition of the nourishment absorbed, but in the opinion of the reviewer he does not present convincing evidence. He found that each species has a minimum requirement for Ca, up to which crystals do not form, and above which they form in proportion as the Ca exceeds the minimum requirement. Since crystals do not form in seedlings grown without any calcium, the author attributes the retarded growth in such cases to deficiency of this element, and concludes that the crystals form under natural conditions to reduce the excess of calcium rather than to remove oxalic acid from solution. The justification for this conclusion is not apparent, because the experiment as tried does not exclude the presence of oxalic acid as a possible factor. In the opinion of the reviewer an important fact has been overlooked, namely that a molecule of oxalic acid consisting of just two carboxyl groups requires only the addition of one atom of oxygen for complete oxidation to carbon dioxid and water. For this reason an abnormal excretion of oxalic acid in animal metabolism has

[23] AMAR, MAXIME, Sur le rôle de l'oxalate de calcium dans la nutrition des végétaux. Ann. Sci. Nat. Bot. VIII. **19**: 197–292. *figs. 34.* 1904.

always been regarded as evidence of incomplete oxidation. Since calcium oxalate occurs in fungi as well as in green plants, it is quite possible that oxalic acid means incomplete oxidation for plants as well as for animals. The author's experiment would then be interpreted thus: an excess of calcium retards oxidation and hence favors oxalic acid formation; rather than that oxalic acid is formed especially to remove excess of lime.—RAYMOND H. POND.

TOBLER [24] experimented at the Zoological Station of Naples upon fragments of living Rhodophyceae taken from the detritus zone of the bay. He finds motion essential to keep the thallus of some algae intact. *Griffithsia Schousboei*, for instance, grew well upon a shaking machine, but fell to pieces in a day when kept quiet. Bornetia, which normally has straight branches, only the claw-like branches about the fruiting organs being hyponastic, in darkness developed such branches at the tip of the plant. Lack of light produces abnormal growth and other effects. For example, alternately branched forms in the dark became oppositely branched, and oppositely branched species became whorled. Terminal cells of *Antithamnion plumula* became elongated, lighter colored, and hair-like. Callithamnion lived three and one half months in complete darkness—longer than it had ever been cultivated in light. Dasya grew more luxuriantly in yellow light. About ten cells from the tip of the axis intercalary growth was induced. Etiolation phenomena represent only a general form of reaction, because cultures of a number of algae in the light show typical etiolation, which the author calls phenomena of degeneration. Intercalary growth may occur normally in Pleonosporium and its relatives, yet it is more common in cultures placed in the light. After eight to fourteen days in darkness every cell of the axis not rarely began to form cross walls. Later, intercalary growth occurred in the large branches also. Adventive sprouts and rhizoid-like branches are common characteristics of degeneration. The cortex, which is an important taxonomic feature in many red algae, was found to be variable. Pleonosporium, which has no cortex in nature, developed one in the dark. The youngest cells of Griffithsia often fell off singly in darkness, and in darkness or in yellow light Bornetia fell into filaments or separate cells. Such isolated cells or cell complexes may bud and develop new plants. In contrast to these forms, *Callithamnion granulatum* often cast off young cells which never formed proliferations, but quickly died. The author explains this peculiarity by the intimate correlation between the cells of Callithamnion, which makes it impossible for them to become separated and remain alive.—ETOILE B. SIMONS.

THE ATTITUDE of experimental morphologists of the present day is decidedly toward a causal explanation for the behavior of organisms, as opposed to the teleological view of the past. REINKE,[25] in a lengthy discussion, strenuously

[24] TOBLER, F., Ueber Eigenwachsthum der Zelle und Pflanzenform. Versuche und Studien an Meeresalgen. Jahrb. Wiss. Bot. **39**: 527–577. *pl. 10.* 1903.

[25] REINKE, J., Ueber Deformation von Pflanzen durch äussere Einflüsse. Bot. Zeit. **62**[1]: 81–112. *pl. 4.* 1904.

opposes this point of view and argues for a "final" (which he makes synonymous with teleological) explanation. REINKE cites as illustrations upon which his argument is based the behavior of *Nuphar luteum* and *Ranunculus aquatilis* which in flowing water produce no floating leaves or flowers, of *Euphorbia Cyparissias* whose shoots are distorted by a rust fungus, and of *Lentinus lepideus* which in darkness develops a branching non-fruiting form. These cases he considers as undoubted malformations because they are forced departures from the normal type. In Nuphar, for example, the form developed in still water is "abnormal," though it always occurs under these conditions. This character, REINKE claims, not being "normal" is not hereditary; only the capability of reaction to this stimulus is hereditary. One is tempted to ask here, what is the "normal" form of this plant but evidence of its capability of reaction to the conditions of still water?

The branched non-fruiting form of Lentinus occurring in the absence of light REINKE discusses at length, and claims it to be a true malformation because it is the result of abnormal conditions, while the fruiting form is "normal" because it is the result of "normal" conditions, the test of normal or abnormal conditions here being very apparently whether they are the rule or the exception in nature. Such "abnormal" modifications according to REINKE all have this character, that they are not necessary for the life of the plant, and are not hereditary, but only potentially so, in that they occur only as reactions to definite stimuli, *i. e.*, the reaction ability is hereditary. When an organism responds to two different sets of stimuli by definite reactions in each case it seems to the reviewer rather futile to argue that one response is normal and the other is anything else.

KLEBS's work is freely quoted, and REINKE, as would be expected, takes exactly the opposite view, maintaining that there is a definite form which the plant is striving to assume, but when certain inhibiting conditions exert their influence the morphological equilibrium is disturbed and the plant, against its innate forces, is compelled to assume another form. These external factors REINKE considers as opposed to the "normal" form, and the plant, so to speak, resists them.—W. B. MACCALLUM.

ITEMS OF TAXONOMIC INTEREST are as follows: K. SCHUMANN (Bot. Jahrb. **34**:325. 1904) has described a new African genus (*Stephanostema*) of Apocynaceae, and also (*idem* 331) one (*Dolichometra*) of Rubiaceae.—W. H. BLANCHARD (Amer. Botanist **7**:1–4. 1904) has published a new species of Rubus (blackberry), with a variety, from Vermont.—H. CHRIST (Bull. Herb. Boissier **4**:936–951. 1904) has described new species of Hymenophyllum (12), Trichomanes (2), Cyathea (9), and Alsophila from Costa Rica.—P. HENNINGS (Hedwigia **43**:353–400. 1904), in concluding his Ule's *Fungi amazonici*, has described as new genera *Saccardomyces* (Englerulaceae), *Zukaliopsis* (Perisporiaceae), *Asteropeltis* and *Phaeoscutella* (Microthyriaceae), *Metadothella* (Pseudophacidiaceae), *Cicinnobella*, *Diplodiopsis*, and *Septodothideopsis* (Sphaeropsidaceae), *Poropeltis*, *Peltistroma*, *Seynesiopsis*, and *Phragmopeltis* (Leptostromataceae), and *Bactridiopsis* (Tuberculariaceae).

—W. LIPSKY (Acta Hort. Petrop. **23**:1–247. *pls. 1–11.* 1904), in his second contribution to the flora of central Asia, which includes Ranunculaceae to Labiatae, besides numerous new species describes two new genera (*Kozlovia* and *Ladyginia*) of Umbelliferae.—A. A. HELLER (Muhlenbergia **1**:63–110. 1904) has brought together the species of Ribes in California, with a key, recognizing 43 species, one of which is described as new; and has also described new species of Heuchera, Sidalcea, Eriodictyon, and Orthocarpus.—E. P. BICKNELL (Torreya **4**:129–132. 1904) has described three new species of Viola from Long Island.—W. A. MURRILL (*idem* 141–142) has described a new genus (*Phylloporia*) of pore-fungi from South America.—N. L. BRITTON (*idem* 142) has described a new species of Bradburya from Florida.—E. L. GREENE (Leaflets **1**:49–64. 1904) has read the riddle of NACKER'S genera of Cactaceae (all of them happily synonyms); has called attention to Amarella as the proper name of the American species referred to Gentiana, describing under it eight new species; and has described seven new species of Apocynum and five new western species of Rhamnus.—ANNA MURRAY VAIL (Bull. Torr. Bot. Club **31**:457–460. *pls. 16–19.* 1904) has published two new species of Asclepias from New York and one from Kansas.—T. D. A. COCKERELL (*idem* 461–509. *pls. 20–23*) has published an account of the N. Am. species of Hymenoxys (formerly referred to Picradenia or Actinella), recognizing thirty species and varieties, describing eleven as new, and transferring seventeen.—J. N. ROSE (Smithsonian Miscell. Coll. **47**:159–162. *pl. 20. fig. 18.* 1904) has published a new genus (*Lenophyllum*) of Crassulaceae, comprising four species from northeastern Mexico and southern Texas.—J. M. C.

A VOLUMINOUS monograph on anthocyanin by BUSCALIONI and POLACCI [26] is in three parts. The first is a bibliography, presumably exhaustive, as it contains 866 titles, among which are Linnaeus's *Flora Lapponica* and Loudon's *Arboretum*. The industry of the authors in gathering titles has exceeded their discrimination, as the inclusion of a paper by a Mr. ROBINSON, entitled *Blue Ridge blossoms*, will testify, since it is purely a floristic list and the Blue Ridge does not owe its color to anthocyanin. The second part (114 pp.) is a critico-historical discussion of the researches of previous authors. The third part (255 pp.) contains an account of the very extensive researches of the authors, which have continued for two years. The gist of their results is here given, condensed from their own summary.

Anthocyanins appear only in highly developed plant forms. Their distribution in the parts of different plants does not accord with that of starch and indicates that they have more than one function, just as their formation depends on more than one factor. Comparative studies show that the presence of anthocyanins often involves a modification of cells. Their origin seems due to oxidases acting on sugars, glucosides, etc., while their decomposition is oftenest due to reduction. The influence of humidity, of nutrition, and of light upon them are very variable.

[26] BUSCALIONI, LUIGI, e POLACCI, GINO, Le antocianine e loro significato biologico nelle piante. Atti Istituto Botanico di Pavia II. **8**: 135–511. *pls.* 9. 1904.

They apparently tend to moderate rather than to accelerate transpiration. The relations of anthocyanins to parasitic organisms show that anthocyanic cells react against the invader by augmenting their osmotic pressure, which is accomplished by accumulating in them substances from which ultimately anthocyanins arise. Thus the pigments at once indicate and participate in the increased turgescence. Study of allogamy leads to the conclusion that floral coloration has not originated from the intervention of insects, but that the crowding of foods into the floral leaves has led first to the starvation of the chloroplasts, later to their modification, and finally to the appearance of the anthocyanic coloration, which became fixed by the agency of insects. To hold that allogamy is the primary cause of coloration seems to require belief that flowers are not only intelligent, but can voluntarily and freely alter their own bodily characteristics with varying external conditions. Finally, as the chromatic evolution of flowers is found to be probably polyphyletic, the anthocyanins can hardly have arisen from the xanthic pigments or *vice versa*. A new reagent for the anthocyanins—a solution of nicotin—is found to be the most reliable.

This monograph, which the authors call *un modesto contributo* to the study of biological problems, suffers from hypertrophy. A more careful bibliography, confined to legitimate references, a compact relation of the discordant results of previous investigators, and a condensed presentation of their own work would have insured wider attention to an important paper than can be given it in its present voluminous form by any except special students of plant pigments.—C. R. B.

THE RECONSTRUCTION of the nucleus and the formation of the chromosomes in vegetative mitoses is the title of an important paper by GREGOIRE and WYGAERTS.[27] The material studied was the roots of *Trillium grandiflorum* and the homotypic division in the pollen mother-cells of *T. cernuum*. The conclusions in many cases differ decidedly from the commonly accepted views.

*Telophase in root tips.* After the chromosomes have reached the poles, one sees surrounding and bathing the mass of chromosomes the liquid which will constitute the nuclear sap. The liquid increases rapidly and causes the formation of the nuclear vacuole and nuclear membrane. On this point the writers are quite in accord with the recent view of LAWSON.[28] Each chromosome, through a gradual process of alveolarization, becomes resolved into a network, so that the entire nuclear network is a network of networks. In the resting nucleus within the membrane the chromatic network, lying in the nuclear sap, is (with the exception of the nucleolus) the only constituent. The nuclear membrane forms in immediate contact with the chromosomes, so that if any cytoplasm is included it is only a few

[27] GREGOIRE, VICTOR, and WYGAERTS, A., La reconstruction du noyau et la formation des chromosomes dans les cinèses somatiques. 1. Racines de *Trillium grandiflorum* et télophase homoeotypique dans le *Trillium cernuum*. La Cellule **21**: 7–76. *pls. 1–2.* 1903.

[28] LAWSON, A. A., On the relationship of the nuclear membrane to the protoplast. BOT. GAZ. **35**: 305–319. *pl. 15.* 1903.

threads of the central portion of the spindle which may become imprisoned. No karyoplasm is formed in the nucleus of Trillium. In passing through the telophase to the resting condition, no continuous spirem is formed.

*Prophase in root tips.* The nuclear network becomes resolved into alveolar or reticular pieces. A process of concentration and homogenization (*sit venia verbo*) continues until the chromosomes have the form of homogeneous rods. There is no continuous spirem in the prophase and the chromosomes never present the form of an achromatic ribbon carrying chromatic granules. The longitudinal division of the chromosomes begins by the formation of a series of chinks lying along its axis and not by the division of granules. In the nuclear cavity there are no granular or filamentous structures, but only the chromatin (and nucleolus) lying in the nuclear sap.

*Telophase of second division in pollen mother-cells.* No daughter thread is formed. The nucleus results from the confluence of one or more vesicles each of which contains one or more chromosomes. A chromatic vesicle in Trillium is a vacuole containing a chromosome bathed in nuclear sap. The nuclear membrane is formed by the condensation of the peripheral layer of cytoplasm bordering the nuclear vacuole.

The writers define the nucleus (excepting nucleoli) about as follows: In Trillium the nucleus is a vacuole limited by a cytoplasmic membrane, filled with a nuclear sap in which lies a chromatic network consisting of a homogeneous ground substance, without differentiation into an achromatic substratum and chromatic granules. The network, which arises from the juxtaposition of the networks of the individual chromosomes, apparently retains its composite character during the resting period, and so might be defined as an association of chromosomes which have become alveolar and reticular.—CHARLES J. CHAMBERLAIN.

STRASBURGER[29] in a very important paper on the reduction division expresses views which are quite opposed to his previous interpretations. The observations and discussion deal almost exclusively with the first division in the mother-cell because there seems to be no ground for interpreting the second division as a reduction division. *Galtonia candicans*, the principal form studied, is particularly favorable, since it has only six chromosomes and is easy to stain. In the pollen mother-cell during the loose spirem stage of the first division the thread shows a longitudinal splitting, but the daughter threads do not separate. The thread becomes shorter, thicker, and simpler, and then divides into six chromosomes which are bivalent, as shown by the fact that each one splits transversely into two. Thus arise twelve chromosomes united in pairs. The pairs assume the various shapes so often observed. After the two parts of each pair have become separated and are nearing the poles of the spindle, a longitudinal fission can be seen. This is the longitudinal fission commenced but not completed in the loose spirem stage. The chromosomes become placed end to end, but are united only by linin threads,

[29] STRASBURGER, EDUARD, Ueber Reduktionsteilung. Sitzungsb. Königl. Preuss. Akad. Wiss. **18**: 587–614. *figs.* 9. 1904.

and are distinguishable during the short resting period. In the second division the chromosomes split longitudinally along the line indicated in the loose spirem stage of the first division. Consequently, it is the product of the first longitudinal division which becomes separated at the second division, and not the product of a second longitudinal splitting as believed by those who support the theory of a double longitudinal splitting. The first mitosis is a reduction division, the second an equal division (*Aequationsteilung*). Besides the figures of Galtonia, a series of diagrams makes the process easily understood. An examination of Tradescantia gave approximately the same results, but in this form the processes are not so easily observed. The much studied Lilium, though not a favorable form, will bear a similar interpretation.

The greatest difficulty in the investigation and the most important part of the discussion concerns the synapsis stage. At this period the chromatin withdraws from the linin thread and collects around twelve centers (*Gamocentren*) corresponding to the twelve chromosomes. The chromatin granules form loose groups, then unite to form bodies in which the separate granules can hardly be distinguished. These bodies elongate, become constricted in the middle, the granules of the two halves begin to separate, and with the aid of the linin form a continuous thread. The entire thread then splits longitudinally. That the twelve bivalent segments of this thread correspond to the twelve bodies counted during synapsis, and that the transverse division of each bivalent chromosome again separates halves of that body, cannot be doubted. The view that there are differentiated chromosomes in the synapsis stage is consequently incorrect. Rather, the chromatin content of the chromosome is in the form of small granules collected about a middle point, the number of these middle points corresponding to the reduced number of chromosomes and to the number of chromosome pairs. One can actually see the granules form a body which becomes divided into halves. STRASBURGER conceives that the granules leave the linin thread that there may be a freer interchange among them than would be possible in the case of differentiated chromosomes. He proposes the term *gamosome* for the individual chromatin granules, and *zygosome* for the body which they form. From each zygosome comes two chromosomes, in the formation of which the linin takes part. The chromatic gamosomes are the bearers of hereditary qualities, the linin having only a secondary significance. The diminution of chromatin during the resting period of the nucleus is not regarded as evidence that the chromatin is not the bearer of hereditary qualities. In synapsis the individuality of the paternal and maternal chromatin is given up. They unite to form a single zygosome, from which come two new chromosomes. These two chromosomes do not contain exclusively paternal or maternal gamosomes. This throws light on the differences in the offspring of a pair of parents and also upon the splitting of monohybrids. In discussing the question whether each chromosome bears all the hereditary qualities of the organism, some evidence is found in favor of the view that the chromosomes are not of equal value.

A fuller presentation of these views and their relation to current conceptions would be welcome.—CHARLES J. CHAMBERLAIN.

# NEWS.

Mr. E. W. D. Holway has been appointed assistant professor of botany in the University of Minnesota.

Professor Girolamo Cocconi, a well known Italian mycologist, died at Bologna, October 6, at the age of 82.

Professor Gaston Bonnier of Paris has been elected a member of the Royal Microscopical Society of London.

August Franz LeJolis, the well-known French marine phycologist, died August 20 at Cherbourg, at the age of 81.

Mr. Clifton Durant Howe, instructor in the University of Chicago, has been appointed instructor in botany in the Biltmore Forestry School. He will enter upon his duties January 1, 1905.

A. H. Reginald Buller, of the University of Birmingham, has been appointed professor of botany in the University of Manitoba, Winnipeg, Canada, and assumed his new duties in October.

The address of Professsor F. O. Bower delivered at the International Congress of Arts and Science, St. Louis, September 1904, was published in *Science* of October 21. He discussed the relation of the axis to the leaf in vascular plants.

Commissioned by the Department of the Interior, the Swiss Scientific Society announces that it will award a stipend of 5,000 francs to enable some Swiss botanist to visit Buitenzorg. Applications are to be sent to Professor Dr. C. Schröter of Zürich.

The Botanical Magazine (Tokyo), in its September number, has begun to publish a résumé of its Japanese papers in some European language. This puts the contents of the journal within the reach of all botanists, and will avoid the compulsory neglect of interesting Japanese contributions.

The lectures given by Professor de Vries at the University of California are being edited by Dr. D. T. MacDougal and will appear in a volume to be entitled *Species and varieties; their origin by mutation*, to be published by the Open Court Publishing Co., of Chicago. The book is promised in January.

The United States Department of Agriculture has now two cooperating gardens established especially for the study of the date palm, one at Tempe, Arizona, and one at Mecca, California. In all probability a third garden may be established near Yuma. The thorough studies under way on the life history of this plant in connection with its introduction into practical culture promise to yield results of interest both to botanists and to horticulturists.

THE REPORT of the Imperial Botanic Garden of St. Petersburg for 1903 contains the following items of general interest: the collection of living plants comprised 34,887 species; during the year there were 40,296 visitors; the herbarium had an accession of 10,808 species (52,421 specimens); the library contained 14,986 works in 30,952 volumes. Attached to the garden are the biological laboratory, the seed-testing station, the central station for plant pathology, and the school of horticulture.

BOTANICAL SUBJECTS for the Walker Prizes have been announced as follows. For 1905, 1. "The life history of any parasitic fungus;" 2. "Contribution to our knowledge of the physiology of plants;" 3. "Study of hybrids in animals or plants;" 4. "Critical study of geographical distribution of species." For 1906, 1. "An experimental field study in ecology;" 2. "A contribution to a knowledge of the nature of competition in plants;" 3. "A physiological life history of a single species of plants;" 4. "Phylogeny of a group of fossil organisms." Address the secretary, GLOVER M. ALLEN, Boston Society of Natural History, Boston, Mass.

THE *Experiment Station Record* states that the order establishing the soil and fertilizer laboratory in the Bureau of Chemistry, U. S. Department of Agriculture, has been abrogated, and in lieu of this laboratory one to be known as the plant analysis laboratory has been established. The laboratory is charged with the examination of fertilizers and will collaborate in this work with the referees of the Association of Official Agricultural Chemists, and with the investigagation of the constitution of plants. It is authorized to collaborate with the Bureau of Plant Industry in the chemical investigation of problems in which the two bureaus are mutually interested.—*Science*.

THE AMERICAN ASSOCIATION for the Advancement of Science will meet in Philadelphia December 27–January 2, and the many affiliated societies gather in the course of this convocation week. Thus, the eleventh annual meeting of the Botanical Society of America is called at this time under the presidency of FREDERICK V. COVILLE. CHARLES R. BARNES, the retiring president, will give an address on *The theory of respiration*. By invitation of the Council special papers will be presented by Professor BALFOUR of Edinburgh and Professor VÖCHTING of Tübingen. On Dec. 28–30, the eighth annual meeting of the Society for Plant Morphology and Physiology will be held. Doubtless the Mycological Society will meet in Philadelphia also in the same week, though announcements have not yet reached us.

There is every indication that these meetings of botanists will be of unusual interest and importance. Among other matters to be considered will be the plan for a union of the botanical societies. Preliminary suggestions for such a union have been sent by the committees of conference to all members for their consideration, and the replies received will be used as a basis for the formulation of a definite plan which will be sent to all members before the meeting. This plan will then form the basis for the discussion at the meetings and for the decision for or against a union.